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A LASCHIA ON CABBAGE PALMETTO

VERA K. CHARLES

(WITH 1 FIGURE)

In view of the fact that *Laschia* has always been considered a tropical genus the discovery of a species occurring on cabbage palmetto in Florida is of special interest. As far as our information goes this is the first record for the United States, although species of *Laschia* on palms have been reported from Panama and Cuba. The occurrence on cabbage palmetto has doubtless been overlooked because of its presence on the lower surface of old, fallen, semi-decayed leaves, also to the fact that the fungus shrivels in drying and is therefore inconspicuous. For three successive years during the months of November, December, January and March the fungus has been sought diligently in different sections of Florida, but the only collections made were at the swamp at Old Faithful, about 22 miles east of Orlando, and at Highlands Hammock west of Seabring. Apparently the fungus is rare for during this period hundreds of old, prostrate leaves were examined and only a few collections made. Possibly it occurs more frequently during other months of the year, but if so it seems as if it would have been observed and recorded previously.

The fungus appears as small nearly sessile, orange yellow, honeycomb-like bodies varying from 1.5–4 mm. in width (FIG. 1, *A*). The shape ranges from nearly circular when young and unexpanded to slightly reniform when mature. With the aid of a hand lens the pores are shown to be hexagonal in shape, conspicuously ciliate, and ranging from 10–20 in number. The specimens shrink and fade somewhat in drying and are then quite inconspicuous as previously mentioned.

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A search of the literature on *Laschia* reveals the necessity for a monographic study of the genus, with particular attention given to microscopic characters. This situation was recognized by Lloyd who had the opportunity to examine material in foreign herbaria, and often found the specimens, particularly the types, too meager or too poor for satisfactory microscopic study. In view of this condition a revision of the genus will be necessary before the true relationship of species can be correctly understood. Lloyd observed (**3**) "There are in our Index 93 names, mostly described as new species of *Laschia* and there are 16, or 1 out of 6 that appear to us to be good and 4 of them are doubtful." From a limited study of the genus we would take this assertion to be true.

Various interpretations of the genus have been made by different authors, but in most instances little consideration has been given to the microscopic structures. Probably Lloyd had the best opportunity of any investigator to examine and study species of *Laschia* and as a result he had a more intimate knowledge of the true character of the genus and of species. For this reason and because of the clarity of his discussion of the genus we feel it may be of interest and convenience to quote his description of *Laschia* (**1**).

"Laschias are very interesting under the microscope and it appears to me have never been correctly observed. They have two conspicuous and different bodies.

"First, most species have conspicuous color cells, or glands as I call them, usually imbedded in the sub-cuticular tissue, but also sometimes projecting from the surface and edges of the pores. In but few species that I have examined are these glands imbedded in the hymenial layer. The glands are always smooth with more or less deeply colored contents, and of three types. First, ordinary, cuticular, irregular cells, filled with coloring matter. Second, gland-like bodies with a short or long stalk (FIG. 1, *B*) mostly imbedded in the sub-cuticular tissue or edges of the pores, and in only a few species examined by me in the hymenium. Third, long, cylindrical color cells embedded in the tissue.

"Second, cristated cells which are always hyaline and crowned or covered with little processes, and are beautiful objects under the microscope. They have been held to be empty color cells but I think this is an error as the color cells are never cristated. They

are of two types. First, oval cells (FIG. 1, *C* from Patouillard) (**5**) crowned with spiny processes, and second, long, cylindrical cells (FIG. 1, *B* by Miss Wakefield from Lloyd) (**1**) covered with spiny processes. Some species which are for me true Laschias have neither of these bodies."

An exhaustive search of literature and an examination of the specimens in the C. G. Lloyd Mycological Collections and of those in the Mycological Collections of the Bureau of Plant Industry revealed no species which agreed both macroscopically and microscopically with the Florida material. The nearest approach was a sessile form of *L. auriscalpium* Mont. (**4**) discussed by Lloyd (**2**). This material was received from Rev. Torrend and described by Lloyd as being of the same color, size and having the same microscopic structure as *L. auriscalpium*. Lloyd believing that the microscopic features were of more importance in the classification of the species than the presence of a stem, considered this a sessile form of *L. auriscalpium* and described it as follows: "Pileus minute 1–1.5 mm. with a short lateral stem of 1 μ. Surface even, color when dried pale almost white, and when soaked has a pale yellow cast. Cristated cells long, cylindrical, beautifully cristate, found on pileus surface and pore edges. Color glands numerous on pileus, edge of pore and scanty on pore surface. Spores 8–10, hyaline, guttulate." Lloyd further states that the cylindrical, cristate cells are not known to him in any other species. The difficulty with this statement is that so few species have been studied microscopically. Lloyd describes the color of *L. auriscalpium* as pale, almost white, but having a yellow cast when soaked. The Florida material was consistently orange yellow.

Montagne did not mention cristate cells in his description of *L. auriscalpium* but stated that because of the very different structure he was at first tempted to make a new genus under the name of *Myxomyces*. This difference appeared to consist in the presence in the exterior layer of the pileus, of large rounded cells in juxtaposition. Montagne likened these cells to the cells found in the trama of *Russula,* evidently a reference to the vesiculose tissue (**4**). We would understand these cells to be the gland-like bodies mentioned by Lloyd in his description of *Laschia* (FIG. 1, *B*). The stalk of these cells is often very short or practically absent, a

condition which doubtless led Montagne to describe them as round cells.

While Lloyd's description of this sessile form (2) suggests the Florida species, the absence of a stipe or occasionally the presence of a rudimentary stipe, the striking color and coronated cells in addition to the cystidia would seem to justify describing the fungus as a new species.

Most species of *Laschia* have been described on dead wood, and so far as we know no species of *Laschia* on palms has been reported from the United States. However, *L. auriscalpium* was described on palms from Cayenne and later reported from Panama and Cuba. *Laschia intermedia* Berk. & Curt. has also been reported on palms from Cuba and Panama. However, Lloyd includes it in a list of species in which the "types" did not exist or were too fragmentary and scanty for any conclusion to be drawn from them. The original description is also too incomplete for a proper understanding of the species. *L. chippii* was described by Lloyd on palm stems, but differs from our material in several respects, especially in the absence of color glands and cristate cells. The species is represented in the Lloyd Collections by 2 specimens collected in Singapore but at different dates.

The Florida fungus discussed in this paper would seem to be clearly different from any known species and is therefore considered as new and described under the name of *Laschia sabalensis*.

Laschia sabalensis sp. nov.

Pileus minute, 1.5–4 mm. membranaceous-gelatinous, applanate, semi-orbicular to reniform, orange-buff fading to light orange yellow (Ridgway), sessile; occasionally subsessile; pores 10–20 in number, ciliate, hexagonal; color glands smooth walled, imbedded in the tissue rarely in the hymenium, broadly cylindrical constricted in the middle, external layer of large rounded cells (vesiculose-like cells of Montagne); cristate cells of 2 types, one type numerous, long, cylindrical with enlarged non-echinulate base, the second type few, broadly oval, apical portion adorned with spiny processes; basidia short, sterigmata, cylindrical; spores hyaline, pyriform, apiculate 4–5 × 9–10 μ.

On dead leaves of *Sabal Palmetto*.

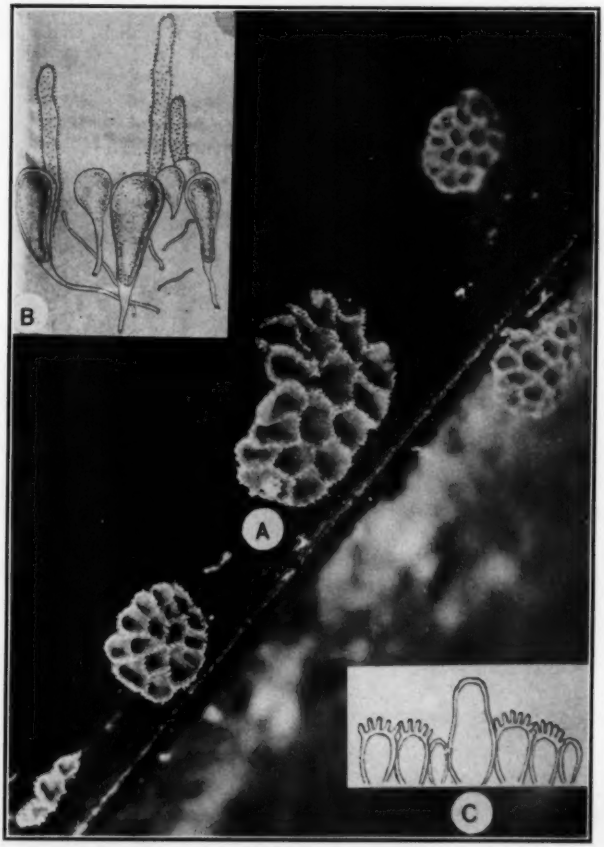


FIG. 1. *A*, fruiting bodies of *Laschia sabalensis* in situ, × 13; *B*, short oval cells and long cristate cells as found in *L. auriscalpium* and *L. sabalensis* (after Lloyd); *C*, section of a gill of *Androsaceus* (*Marasmius*) *haematocephalus* illustrating oval cells with spiny processes such as also occur in *Laschia sabalensis* (after Patouillard).

Pileo minuto 1.5–4 mm. gelatinoso membranaceo, applanato, subrotundato, subreniformi, aurantiaco-luteo, pallescente usque pallide aurantiaco-flavo sessili vel interdum subsessili; poris 10–20, insigne ciliatis, hexagonis; cellulis pigmentatis glabrotunicatis in textura immersis, rare in hymenio, late cylindricis, medio constrictis; cellulis magnis, subsphaericis in strato externo praesentibus, cellulis cristatis biformibus, aliis numerosis, longis, cylindricis

basi subbulboso, non-echinulato, aliis paucis, late ovoideis, apice solum echinulatis; basidiis sterigmatibus brevis, cylindraceis; sporis hyalinis, piriformibus, apiculatis, 4–5 × 9–10 μ.

Hab. in foliis emortuis *Sabalis Palmetto*.

Type collected at Highlands Hammock, Fla., by V. K. Charles, Mar. 3, 1941. Deposited in the Mycological Collections of the Bureau of Plant Industry, Washington, D. C., No. *71360*.

Additional collections:

Myc. Colls. No. *71361* C. L. Shear, Kissimmee, Fla., Nov. 1923.

Myc. Colls. No. *71362* C. L. Shear, Old Faithful, Orange Co., Fla., Dec. 30, 1940.

LITERATURE CITED

1. **Lloyd, C. G.** Myc. Writ. **5**: 831–832. 1919.
2. ——. Myc. Writ. **5**: 835–836. 1919.
3. ——. Myc. Writ. **5**: 838. 1919.
4. **Montagne, C.** Cryptogamia Guyanensis. Ann. Sci. Nat. IV. **1**: 136–137. 1854.
5. **Patouillard, N.** Sur les Familles et les Genres des Hymenomycètes 140. *fig. 67, 8.* 1900.

BUREAU OF PLANT INDUSTRY,
WASHINGTON, D. C.

A NEW MONOBLEPHARELLA FROM MEXICO

LELAND SHANOR

(WITH 20 FIGURES)

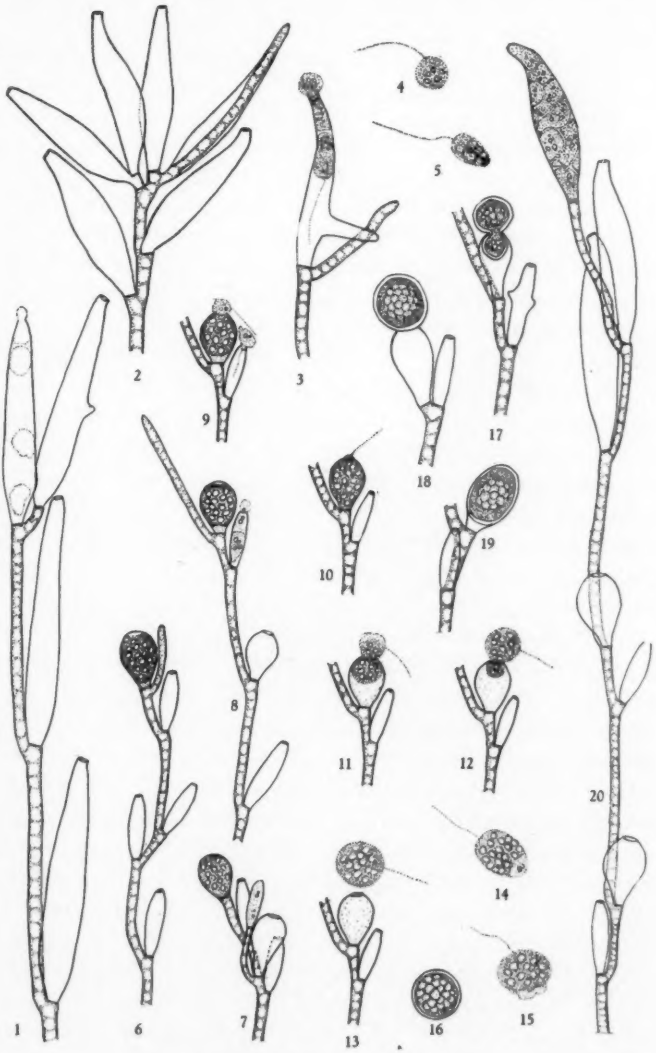
Among other aquatic Phycomycetes recovered by the author from soil samples collected for him in Mexico during the summer of 1941, by William C. Leavenworth and Martha M. Leavenworth of the Fourth Hoogstraal Biological Expedition to Mexico, there appeared a species of *Monoblepharella* heretofore unreported. These soil samples were collected in July and allowed to dry thoroughly at that time, then were carefully packed in separate containers. They were brought to the Botanical Laboratories of the University of Illinois in September where they were placed in jars in sterilized distilled water to which several types of substrata suitable for aquatic Phycomycetes had been added. These bits of substrata were examined at regular intervals and the fungi recovered were isolated and identified each time. Hemp seed in the three jars containing soil samples from stations on the north side of Mt. Tancitaro, State of Michoacan, when examined on November 3, were luxuriantly covered with the pearly gray mycelium of a very delicate fungus. An examination of these hyphae showed that they resembled those of *Monoblepharella Taylori* Sparrow. After cultures had stood on the laboratory table for over ten days and only sporangia appeared on the hyphae, they were placed in a constant temperature oven held at 30° C., a procedure recommended by Sparrow (**1940**), in an attempt to induce the formation of sexual organs. After three days at this temperature, cultures were found to be producing antherida and oögonia in abundance. The position of the gametangia on the hyphae and their sequence of formation readily distinguish this plant from *Monoblepharella Taylori* and warrant its description as new.

Monoblepharella mexicana sp. nov.

Mycelium well developed, hyphae delicate, 1.5–5.5 μ in diameter, much branched, branches usually growing almost at right angles to the main hyphae, contents reticulately vacuolated; sporangia narrowly cylindrical or siliquiform, variable in size, 40–95 μ in length by 6.5–10 μ in diameter at the widest point, occurring singly or in clusters due to marked sympodial branching of the supporting hypha; zoöspores ovoid to subcylindrical, 6.6–10 μ long by 4–5 μ in diameter, posteriorly uniciliate, cilia up to 36 μ long; oögonia at first terminal but often becoming lateral due to the sympodial branching of the supporting hypha, obpyriform with somewhat rounded apex and a narrow cylindrical base, 14–17 μ long by 9–15 μ in diameter, tapering to 2–4 μ at the base, containing usually a single egg in which there are numerous large refractive globules; antheridia terminal or after sympodial branching of the supporting hypha appearing lateral, narrowly cylindrical or fusiform, 14–16 μ long by 4–6.5 μ in diameter; antherozoids 2–8, amoeboid, posteriorly uniciliate, ovoid when swimming, 4–6 μ long by 2.5–3.7 μ in diameter, normally containing 2–4 strongly refractive globules; zygote broadly ovoid to nearly spherical, 10.5–13.6 μ long by 8–10 μ in diameter, free swimming or becoming stationary at oögonial orifice; oöspores formed free in the water or within oögonium or at its mouth, normally spherical, 10–13 μ in diameter with a slightly thickened, amber to light brown, smooth wall, contents containing many large refractive globules, upon germination forming a mycelium.

Mycelium amplum, hyphis tenuibus, 1.5–5.5 μ diametro, ramosis; sporangia anguste cylindrica vel siliquiformia, valde variabilia, 40–95 μ longa, 6.5–10 μ diametro, zoosporis ovoideis vel subcylindricis, 6.6–10 μ longis, 4–5 μ diametro, postice uniciliatis, ciliis usque ad 36 μ longis; oogonia primum terminale formata, serius quasilaterale, obpyriformibus, 14–17 μ longis, 9–15 μ diametro, cum apice rotundo et basi anguste cylindrico, 2–4 μ diametro; ova singula, cum globulis magnis refractivis; antheridia primum terminale formata, serius quasilaterale, anguste cylindrica vel fusiformia, 14–16 μ longa, 4–6.5 μ diametro, antherozoideis 2–8, amoeboideis, postice uniciliatis, ovoideis si natantibus, 4–6 μ longis, 2.5–3.7 μ diametro, cum globulis refractivis 2–4; ova inseminata late ovoidea vel fere sphaerica, 10.5–13.6 μ longa, 8–10 μ diametro, natantia; oosporis in aqua libere formatis, sphaericis, 10–13 μ diametro, membranis paulo incrassatis sucinaciis vel pallide brunneis, levibus in germinatione mycelium formantibus.

In soil from wet meadow along stream on North side of Mt. Tancitaro, Tancitaro Province, State of Michoacan, Mexico, at an altitude of 10,000 feet, July 24, 1941.



FIGS. 1–20. *Monoblepharella mexicana.*

Slides of preserved material from the type cultures are being deposited in the herbaria of the University of Illinois, the University of North Carolina, the University of Michigan, the Farlow Herbarium of Harvard University, and in the Mycological Collection of the Bureau of Plant Industry, Washington, D. C.

OBSERVATIONS

Details of sporangium formation and stages in zoöspore development and discharge in this species are essentially similar to corresponding stages carefully described by Sparrow (**1933**) for *Monoblepharis*. It would be superfluous to repeat similar details for *M. mexicana*, but there are several points concerning the morphology of this new species that should be recorded.

Globose to somewhat spindle-shaped swellings often are formed at various places on the hyphae. These are considered to be normal structures and not abnormalities caused by the presence of a parasite, as might be suspected. Branches usually arise almost at right angles to the main hyphae. There is regularly no definite relationship between swellings on the hyphae and the position at which branches arise.

Although sporangia are terminal in origin, later they appear in a lateral position due to the sympodial branching of the hypha (FIG. 1, 3, 20). In old cultures the length of the portions of a hypha between sporangia is often so short that they appear to be formed somewhat in clusters (FIG. 2). The apex of a large number of the sporangia is definitely curved (FIG. 1, 3, 20) and pronounced papillate outgrowths often appear at various places along the sporangial walls (FIG. 1, 3). I have never observed any of these functioning in the capacity of exit tubes for the zoöspores regularly escape through a pore at the apex of the sporangium. In contaminated cultures, the largest spores often plug the exit pore so that all remaining spores are trapped within. These germinate later by the formation of germ tubes which penetrate the sporangial wall. From these germ tubes delicate hyphae develop and extend some distance out into the water.

Both oögonia and antheridia originate in a terminal position but later appear to be lateral due to the sympodial branching of the

hyphae on which they are formed. As a rule an antheridium is cut off first at the tip of a hypha which is producing gametangia, with additional sexual organs being cut off from the hypha as it elongates. Several antheridia may be formed in this way before any oögonia are produced (FIG. 6), but most commonly antheridia and oögonia alternate on a branch which bears sexual organs (FIG. 7, 8, 20). In young cultures gametangia are usually spaced some distance apart but often in older cultures they are formed rather close to each other, appearing to be somewhat in clusters (FIG. 7). The antheridium is never cut off in a hypogenous position from the hypha supporting an oögonium as is the case in *M. Taylori,* so the two species are easily distinguished by the position of the male reproductive organs.

The behavior of the gametes during fertilization and of the zygote which results from this fusion is, for the most part, like the behavior of those of *M. Taylori* (Sparrow, **1940**). In cultures badly contaminated by bacteria, some of the zygotes frequently either fail to emerge from the oögonium or emerge but do not have a swarming period. In the latter cases the zygote tumbles and turns a few times before finally coming to rest to mature at the oögonial orifice. In these instances the position where oöspores are formed is the same as that considered to be typical of *Monoblepharis* and, were it not for observations on relatively clean cultures, the presence of many oöspores at the mouths of oögonia would give the impression that this species is a *Monoblepharis* rather than a *Monoblepharella.* The motile nature of zygotes, however, is easily observed in cultures in which there is a rather low bacterial population. Even in badly contaminated cultures some of the zygotes undergo a swarming period.

DISCUSSION

The oögonia and antheridia of *Monoblepharella mexicana* are similar to the structures suspected of belonging to the sexual stage of *Monoblepharis ovigera* Lagerheim as described and figured by Sparrow (**1933**, fig. 27 particularly). As a result of observations on *M. mexicana,* the author is of the opinion that Sparrow's original conclusion regarding these structures which he observed was

correct and also that Sparrow's (**1940**) more recent suggestion that *M. ovigera* should be transferred to *Monoblepharella* is very likely. It would seem advisable, however, to postpone this transfer until *Monoblepharis ovigera* can be reëxamined and studied carefully so that the details of the sexual nature of this species can be clearly established.

The marked differences in relative size and shape of the majority of sporangia of *Monoblepharella mexicana* and those of *Monoblepharis ovigera*, apparently would prevent our considering these two as synonymous.

SUMMARY

A new species of *Monoblepharella* is described as *M. mexicana*. This fungus was recovered from soil samples collected in a wet meadow along a stream on the north side of Mt. Tancitaro, State of Michoacan, Mexico, at an elevation of 10,000 feet. It is distinguished from *M. Taylori* by the position of the sexual organs on the hyphae and by their sequence of development. In the present species no part of the antheridium ever occupies a part of the supporting hypha cut off directly below an oögonium. Under poor environmental conditions oöspores may be formed in the oögonium or at its orifice as typical for *Monoblepharis*.

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LITERATURE CITED

Sparrow, F. K., Jr. 1933. The Monoblepharidales. Ann. Bot. **47**: 517–542. *pl. 20.*

——. 1940. Phycomycetes recovered from soil samples collected by W. R. Taylor on the Allan Hancock 1939 Expedition. The Univ. of So. Calif. Pub., Allan Hancock Pacific Exped. **3**: 101–112. *pl. 16, 17.*

EXPLANATION OF FIGURES

All drawings were made with aid of a camera lucida and are approximately × 567 as here reproduced.

FIG. 1, portion of hyphal tip from a young culture showing typical arrangement of sporangia; 2, portion of hyphal tip from an old culture showing cluster of sporangia through one of which the hypha is proliferating; 3,

portion of hyphal tip bearing a sporangium with a marked papillate outgrowth; 4, zoöspore drawn just at the moment of becoming free from the sporangium; 5, zoöspore in swimming condition; the refractive globules are clustered at the anterior end; 6, hyphal tip bearing gametangia; four antheridia were produced in this case before the first oögonium was formed; 7, hyphal tip with group of gametangia as frequently encountered in badly contaminated cultures; 8, hyphal tip showing typical sequence of gametangia; male and female gametangia usually alternate on a hypha in this manner; 9–13, the terminal pair of gametangia shown in figure 8 illustrating further stages in emergence of male gametes, fertilization of the egg, and escape of the zygote; 14, normal motile zygote; 15, an amoeboid zygote; 16, mature oöspore formed free in the water; 17, oöspore formed partly outside and partially within an oögonium; note papillate antheridium; from an old contaminated culture; 18, oöspore formed at oögonial orifice as is typical of *Monoblepharis;* from a badly contaminated culture; 19, oöspore formed within an oögonium; from a badly contaminated culture; 20, portion of a hyphal tip showing gametangia and sporangia; the sporangia developed on the hypha after the culture was removed from the constant temperature oven.

NOTES ON THE MYCETOZOA—VI

ROBERT HAGELSTEIN

The season of 1941 was a very unsatisfactory one for the development of the fruiting bodies of the Mycetozoa, in fact the most discouraging we have ever encountered. Mr. Rispaud and I spent six weeks collecting in New York, Pennsylvania, Ontario and Quebec, and the same conditions prevailed everywhere. There had been no early spring rains, and during the best months, the occasional showers were followed by long periods of dry weather. Nearly two weeks of intensive search in Ontario and Quebec yielded only 45 species. Often, in years gone by, we have seen that many or more in a single day. The entire season's results were 94 species, yet, not disheartening, as among them was a known species and a recognized variety which we had never collected before. Also, during the Foray of the Mycological Society of America in Quebec, in late August, a new species was found, and described in a recent number of MYCOLOGIA as *Badhamia Dearnessii*.

When conditions are not at their best, we must depend on accidental discoveries and the humor that sometimes accompany them in order to enliven our spirits and enable us to carry on. In early September, our car was parked along a mountain road in the Catskill mountains. On one side was the steep slope of the mountain, and on the other, a deep valley. Our young associate, Bobby, the eleven year old son of Mr. Rispaud, was more intent on chasing butterflies and insects than working, although he gets a small stipend for a good find. A grasshopper lit on the grass along the road. Bobby grabbed with his hand, and on opening it, found no grasshopper but a few stems of weeds. He ran to us exclaiming he had plasmodiocarps, and so it was—he got a nickel. He had beautiful plasmodiocarps of *Didymium anellus* Morg. It seems a road gang had cut the grass and weeds on both sides of the sunny road, removing most of the debris, but leaving a few stems. On

these were more developments of *D. anellus* and several other species, but nothing else was found in the vicinity. Who would ever think of looking over so unpromising a spot? A few years ago, when Bobby was younger, and on a warm day, we stopped our car alongside a large tree in Pennsylvania, and entered the forest. Suddenly, Bobby approached and greeted us with the remark "if you will buy me an ice cream cone, I will show you the biggest *Lycogala* in the world." Sure enough, within reaching distance on the living tree beside the car was a large, perfect aethalium of *Lycogala flavo-fuscum* (Ehr.) Rost. We usually guide a party or two each year to Albertson, our favorite collecting ground on Long Island. On one of these occasions, with fifteen enthusiasts present, not even the scent of a slime mold was noticed—Mr. Rispaud says he can smell them. Disconsolate and apologetic, we rested with the party on the trunk of a large, fallen tree before leaving for our homes. Then, in front of us, 30 feet away and 15 feet above the ground on a living tree, were seen two fine aethalia of *L. flavo-fuscum*. Somebody climbed the tree and got them, because, not like the exaggerative fisherman who always loses the largest one, we always get ours.

Several of the students with whom I have contacts, do not seem to have a clear conception of the differences between *Stemonitis* and *Comatricha* as seen by a rough, superficial examination of the sporangia. In the genus *Stemonitis* the sporangia are cylindrical, and usually long in relation to their breadth. Occasionally the tops are frayed, or attenuate from collapse of the capillitium. Some species of *Comatricha* are similar, but can be separated on other characters by the microscope. If the sporangia are globose or ovoid, the form is a *Comatricha*, and, also generally, if shortly cylindrical, although some species of *Stemonitis* are that way.

In the following notes the year 1941 is meant when no other year is given, and the collections were made by Mr. J. H. Rispaud and myself in company, unless otherwise indicated.

AMAUROCHAETE FERRUGINEA Macbr. & Martin. A part of the type material in the Herbarium of the New York Botanical Garden was examined. The specimen is poorly developed and weather worn, and surely not an *Amaurochaete*. There are no signs of a cortex, nor of a confluent or anastomosing capillitium. It consists

of separated sporangia with long stalks and columellae. The stalks are weak and irregular, and recumbent so that the sporangia are intertwined. The spores are the same as those of *Stemonitis splendens* Rost., minutely and closely, but distinctly warted, and a trifle paler than usual. There is no surface net to the weak capillitium. It is the form known as *Stemonitis splendens* Rost. var. *flaccida*. Such forms are often found. N. Y. B. G. No. *6898*.

AMAUROCHAETE TRECHISPORA Macbr. & Martin. This is no more than an erratic phase of *Stemonitis trechispora* Macbr. I have seen the latter species forming year after year in many developments at one time, and it is very variable in every particular. An examination of a specimen of *A. trechispora* from the type collection made by Dr. J. H. Faull discloses nothing that may not be found in *S. trechispora*. In a note (Mycologia **28**: 615. 1936), I have already mentioned that some collections of *S. trechispora* resemble *Amaurochaete*. It is fallacious to take such a collection and regard it as a species of *Amaurochaete*, which it is not, and which it only resembles. *S. trechispora* must be accepted as a whole, with wide departures on one side to the genus *Amaurochaete*, and on the other toward *Stemonitis fusca* Roth. It is abundant wherever it develops and easily recognized. The principal determinative characters are the habit and habitat as described in the earlier note cited. N. Y. B. G. No. *6897*.

BADHAMIA AFFINIS Rost. We have collected this species frequently in areas visited, usually on cottonwood poplar or locust wood, and often in large developments, so that it must be common during certain periods of the season. There is much variation in the form or shape of the sporangia. When seated on short, black stalks, they are flattened or discoid, more or less concave above and beneath. The same shape occurs in sessile sporangia, and there are others subglobose, hemispherical, annulate, curved, or forming short plasmodiocarps. Often several or all of these phases are found in the same development, and again, an entire fruiting may consist of a single phase. The lime in the capillitium may be denser at times, and the lime in the peridium may be so that the wall is smooth or rugulose, or in all gradations to almost limeless. The spores in all our collections are violet-brown, and range from 10–15 μ diam., generally about 11 or 12 μ. This is my conception

of the species as described in the 3rd edition of the British Monograph. Miss Lister regards *Badhamia orbiculata* Rex as a variety covering the discoid or flattened forms.

The treatment of the species by Macbride and Martin in the Myxomycetes is different. They regard *B. orbiculata* as a distinct species, although our collections show flattened, discoid sporangia in the same developments with convex or hemispherical ones. They mention slight differences in size, peridium and capillitium between *B. affinis* and *B. orbiculata,* but these are insignificant and may be noticed in nearly every collection of sporangia with different shapes. Aside from these, the important difference recognized is the size of the spores, which is given as averaging 16–17 μ diam. for *B. affinis,* citing material collected by Morgan in Ohio with spores up to 18.5 μ diam. Occasional specimens with an extreme spore range are known, but I doubt they are common. It seems unreasonable to me to regard this as the final, important character of *B. affinis,* particularly as Rostafinski wrote the spore-size of the species, 12.5–15 μ. The Lister conception of the species covering all ranges of sporangial shape, and with spores 10–15 μ diam., seems to me to be the proper one.

In my note (Mycologia **28**: 569. 1936), I advocated the retention of *B. orbiculata* as a distinct species on the ground of unusual sporangial formation by the plasmodium. Much additional material has come since then, and a study of this indicates that the formation is not confined to the discoid sporangia alone, but is more or less common to all shapes of sporangia of *B. affinis. B. orbiculata* cannot be regarded as more than a variety of *B. affinis.*

Small portions of a colony of *B. affinis* are often difficult to determine as they may simulate phases of other species of *Badhamia.* A complete fruiting will usually show the all important flattened sporangia, and the small circular or linear depressions characteristic of the species and due to sporangial formation.

BADHAMIA CAPSULIFERA (Bull.) Berk. It was gratifying to find this species because it is rare, with only a half dozen or so specimens from eastern North America in the Herbarium of the New York Botanical Garden. The fruiting is very small covering less than two square cm. in area. The sporangia are firmly sessile;

the spores are in clusters, dark, strongly spinulose over two-thirds of the surface only, and measure 12 μ diam.

The rarity of collection is probably due to the small size of the developments which are not easily discovered when solitary. The present specimen was found among numerous, small collections of various species of *Badhamia* taken from a pile of fire wood at West Fulton, Schoharie County, New York, in early September. It might have been passed over as not impressive enough to keep. The spores in the species are not always uniformly clustered throughout an entire colony, and may become free in some sporangia. I was satisfied from the appearance of the spores that they should be adherent, but it was necessary to examine several sporangia to find the clusters. In others they were free. N. Y. B. G. No. *2468*.

BADHAMIA CINERASCENS Martin. Dr. William R. Maxon, of the United States National Museum, has courteously permitted me to examine the type specimen of this form. The development covers about one square cm. of surface, and consists of several dense clusters of grayish white sporangia, some superimposed and others confluent. The clusters appear to be sessile, but the presence of a yellowish hypothallus, with vestiges of yellowish stalks—which may have born sporangia—indicate that perhaps there are similar stalks below the clusters. This cannot be confirmed without ruining the small amount of material. Some of the sporangia are subglobose, the majority of various irregular shapes, reniforme or elongated, and often compressed. The thin membranous sporangial wall is densely covered with clusters of white lime-granules. The capillitium is clearly that of a *Physarum*, although appearing *Badhamia*-like. It consists of numerous short, hyaline threads connecting many large, angular or branching lime-knots. The spores vary much in shape, size, and even color, in the different sporangia, so that it is somewhat difficult to understand them. The normal shape appears to be spherical, although there are many irregular ones that cannot be fully swollen. The general diameter is about 12 μ, with many smaller down to 8 μ, and numerous large, spore-like bodies up to 25 μ diam. The general color is a dull purplish brown with a tinge of gray, not very dark, besides which there are many spores much paler. These conditions indicate im-

perfect development, and this is borne out by the presence, in some sporangia, of agglutinated spores that come out as a mass with the capillitium, instead of separated as in a perfect development. The spores are spinose, and while dark and prominent, the spines are not long, and can just be seen on the borders of the spores. The spines are arranged irregularly, with smooth areas here and there that have no spines. These areas appear paler by contrast with the dark, adjoining spines, but have the same color as the rest of the spore. Sometimes the areas are linear, and there may be several of these on a spore, or they may cross. They are different on every spore that has them, and are not reticulations, but due entirely to the arrangement of the spines.

The habit, shape of sporangia, capillitium, and spores are characteristic of the tropical species *Physarum reniforme* (Massee) Lister. I have no doubt the specimen is a somewhat imperfect development of that variable species.

BADHAMIA DEARNESSII Hagelstein. The species was described in the January–February number of MYCOLOGIA. While going over some old material after the description was in press, I discovered that the species was also found at Brassua Lake, Somerset County, Maine, in August 1936. The spores are identical with those of the Quebec collections, having the pale, narrow, spinulose bands around them. N. Y. B. G. No. *3501.*

BADHAMIA PANICEA (Fries) Rost. The species is far more abundant than the rare *Badhamia macrocarpa* (Ces.) Rost., but so close in some of its characters, at times, that undoubtedly it is often confused therewith. In typical examples the capillitium is coarse, aggregated at the base with a pseudo-columella, and the spores are pale lilac-brown, obscurely warted or spinulose, and about 11–12 μ diam. In typical examples of *B. macrocarpa* the capillitium is not so coarse, not confluent to form a pseudo-columella, and the spores are dark purplish brown, with thick walls, strongly spinose, and measure 10–15 μ diam. *B. panicea* has a character which is nearly always present in greater or lesser degree when an entire fruiting is studied. There is a dark red hypothallus, or reddish bases to the sporangia indicating the hypothallus, and occasionally, short, stranded, reddish stalks. Rarely these may be pale yellowish like in *B. macrocarpa,* but in the latter species they are never red. The

capillitium of *B. panicea* may be more delicate, approaching that of *B. macrocarpa,* and the spores are frequently darker in color and more spinulose. Forms with darker spores, and paler on one side belong to var. *heterospora* G. List. which we have found in Schoharie County, New York. Similar spores, not paler on one side, are difficult to distinguish from *B. macrocarpa* unless other characters are present. The habit helps sometimes in making a decision. In *B. panicea* many sporangia may be united and angled by mutual pressure. *B. macrocarpa* often forms small clusters of united sporangia. This is not of great value, however, as more often in both species there are many separated sporangia and the appearance is similar. Neither species has the flattened sporangia of *Badhamia affinis* Rost.

COMATRICHA RISPAUDII Hagelstein. Found again in Pike County, Pennsylvania, in August. The large development was on moss but in poor condition because of age and molds. The species was also collected by Dr. Erdman West near Gainesville, Florida, in June 1940. I had the pleasure of meeting Dr. West in February, 1941, and he took me to the identical spot where the collection was made. It was similar to all other places where the species has been found heretofore, a dry part of a wet area. N. Y. B. G. Nos. *2548, 9351.*

CRATERIUM PARAGUAYENSE (Speg.) List. Collected by Dr. Erdman West near Gainesville, Florida, in June 1939. Dr. West says he has found the species on several occasions, and that it appears to be fairly common in Florida, often on fallen Spanish moss. N. Y. B. G. No. *9333.*

CRIBRARIA ATROFUSCA Martin & Lovejoy. I have examined a specimen of this form marked cotype *1449,* collected by Dr. E. Bethel in Colorado. The specimen consists of very dark, globose and piriform sporangia, the dark color due to the great abundance of the large, dark, plasmodic granules in the calyculus and nodes. The granules in the calyculus form narrow, radiating areas from the base upward, close together, and separated by similar, narrow areas of paler granules. Frequently, there are aggregations of the darker granules in the pale areas, and when these coincide with similar ones in other pale areas, they form areas like rings around the calyculus. They may, however, be interrupted, short, or ir-

regular, and besides there are often masses of dark granules which do not form rings or lines. The spores are brownish, practically smooth, and measure about 8 μ diam.

The general characters of this form, the presence of piriform sporangia, the large plasmodic granules, and the darker spores, are the diagnostic characters of *Cribraria piriformis* Schrad. In the latter species the number of the plasmodic granules varies, sometimes in the same colony, causing darker or paler colors in the sporangia. They may be uniformly distributed so that radiating areas are absent, or they may be densely aggregated in the upper part of the calyculus. In European specimens here, they are massed at the edge to form a broad border around the calyculus. Any sort of variation in the distribution of the granules may be expected, but can hardly be regarded as a basis for a distinct species. *C. atrofusca* is a phase of *C. piriformis*. N. Y. B. G. No. *7122*.

CRIBRARIA DICTYOSPORA Martin & Lovejoy. I have examined a portion of the cotype of this species (S. U. I. *1436*) kindly furnished by Prof. G. W. Martin. The species is based upon the reticulate appearance of the spores, although many do not show this. The reticulations are not raised ridges, nor spines arranged in uniform, reticulate fashion. The spores are warted or spinose, rather difficult to say positively because of the faintness of the markings, although I believe they are spines from their appearance on the borders of the spores. The spines are irregularly arranged in patches, with smooth, spineless areas between the patches. Often the smooth areas are linear, and may then be long, short, broken, crossing, or joined, and forming a roughly appearing coarse reticulation. They are not uniform, and spores with fairly similar markings are rare. It will be seen from this that the real character is the arrangement of the spines, and not the effects it produces.

Spores with a similar arrangement of warts or spines are found in a number of species in other genera, but usually accompanied by other characters which firmly establish the species. While there is nothing otherwise to distinguish *C. dictyospora* from *Cribraria piriformis* Schrad., the character seems to be of sufficient importance in the present genus, where it is unique, and so far unknown

in any other member. Generally, the spores of specimens of *Cribraria*—readily recognized by other characters—are not critically examined by the most refined methods of observation, as these are tedious and time consuming. If later studies should show that the arrangement of spines or warts as seen on the spores of *C. dictyospora* is also present on the spores of other species of *Cribraria*, the importance of the character would be lessened. N. Y. B. G. No. *7125*.

CRIBRARIA LAXA Hagelstein. The species was found again on leaves at the type locality, Long Island, New York, in July. N. Y. B. G. No. *2080*.

DIDERMA SIMPLEX (Schroet.) List. A curious and finely developed phase of this species was collected in Pike County, Pennsylvania, in August. The sporangia have the hollow columellae, so often present, besides, in many of the sporangia are long, spiky processes extending from the wall or columella. Many other sporangia have on the outside a dense sprinkling of large, hyaline masses of a mineral nature, which may be lime, although there is no reaction to hydrochloric acid. N. Y. B. G. No. *2563*.

DIDYMIUM STURGISII Hagelstein. On the wood pile at West Fulton, Schoharie County, New York, previously mentioned, was found in September a fruiting of this species which differs only slightly from those reported from Wayne County, Pennsylvania, in Mycologia **29**: 397. 1937. The plasmodiocarps are a little thicker and more pulvinate, and there is a tendency to form small, circular sporangia with circumscissile dehiscence. The wood on which it appeared was taken home, and there another development appeared about four weeks later. N. Y. B. G. Nos. *2464, 2485*.

ENERTHENEMA MELANOSPERMUM Macbr. & Martin. Quite naturally, a proposed new species in the genus *Enerthenema* must bear a general resemblance to *E. papillatum* (Pers.) Rost., the type species, because of the restricted, sharply defined, generic characters. The present form does, but the large, black, robust sporangia with stout stalks, the larger and darker spores, and particularly the large apical discs, larger than many sporangia of *E. papillatum*, entitle it to separation as a distinct species. We have found many developments of *E. papillatum* throughout the eastern states, some of large sporangia, others of small ones, dark or pale

in color, but nothing that approaches *E. melanospermum*. The form comes from our northwestern mountains which have produced *Comatricha Suksdorfii* Ellis & Ev., and the latter bears the same resemblance to *Comatricha nigra* (Pers.) Schroet., that *E. melanospermum* does to *E. papillatum*. N. Y. B. G. No. *7228* (portion of type).

FULIGO CINEREA (Schw.) Morg. It is worth while making notes of the time required by different species to go through the entire life cycle under natural conditions. Sometimes this may be observed without outside, confusing, factors. On a pile of decaying plant remains in the rear of Mr. Rispaud's home, appeared on August 10th many aethalia of *F. cinerea*, and on September 6th, new, abundant fruitings again appeared. Other species were not present on either occasion. It is reasonable to assume that this species requires about four weeks to go through the cycle from germination of the spores to maturity of the new fruit. N. Y. B. G. Nos. *2081, 2082*.

KLEISTOBOLUS PUSILLUS Lipp. Found again in Pike County, Pennsylvania, in August. N. Y. B. G. No. *2592*.

LAMPRODERMA ATROSPORUM Meylan. The species was found by Dr. J. Walton Groves, at Burnet, Quebec, in May 1939. It was also collected by Dr. C. L. Shear in the Yosemite Valley of California, in August 1915. Both specimens have the characteristic capillitium, dark to the tips, and attached to the sporangial wall. The California specimen has spores which are beautifully reticulated with spines. In the Quebec one, the spines are more or less confluent, forming a broken reticulation of raised ridges, accompanied by spines. N. Y. B. G. Nos. *7248, 9893*.

LAMPRODERMA MUSCORUM (Lév.) Hagelstein. Two further collections of the species have been made, one at McLeans, near Ithaca, New York, in August 1935, and the other at Angels, Wayne County, Pennsylvania, in July 1941. The sporangia look like those of *Lamproderma scintillans* (Berk. & Br.) Morg., but the spores are marked with large scattered spines, and measure 10–12 μ diam. N. Y. B. G. Nos. *2608, 3193*.

LICEA CASTANEA G. Lister. In April and October 1929, we made extensive collections of *Licea biforis* Morg. on the thin, inner, layers of the bark of a dead willow tree near Hempstead, Long

Island. There were fresh developments on each occasion, and the remains of many earlier ones. Much of the material was distributed as Nos. *1382* and *1383*.

Last winter, while going over the material again to prepare some more specimens, I came across a single sporangium of an unusual *Licea* among those of *L. biforis*, and careful search revealed a few more perfect sporangia, and many bases of prior fruitings. They are subglobose or lengthened, about the size of the sporangia of *Licea minima* Fries, areolated with prominent lines of dehiscence, and with a dull, chestnut-brown color. The spores are free, globose, almost colorless and smooth, about 10 μ diam. In mass they are pale olive-yellow. The sporangia are those of *L. castanea*. They agree in almost every respect with collections of the species made by Prof. Charles Meylan, in Switzerland, except that in the latter the spores range a trifle larger up to 12 μ diam. The Swiss collections are also on the inner side of bark. The species differs from the associated *L. biforis* in shape and dehiscence, and in the latter, the spores are distinctly pale yellow, with many spores of a true, ellipsoid shape. N. Y. B. G. Nos. *2103, 2104*.

ORCADELLA Wingate, Proc. Acad. Nat. Sci. Phila. **1889**: 280. I propose to broaden the genus to include *Orcadella operculata* Wing. l. c., **Orcadella parasitica** (Zukal) Hagelstein comb. nov. (*Hymenobolina parasitica* Zukal Oester. Bot. Zeitschr. **43**: 133. 1893) and **Orcadella pusilla** (Lipp.) Hagelstein comb. nov. (*Kleistobolus pusillus* Lipp. Verh. Zool.-Bot. Ges. Wien **44**: 70. 1894). It seems unnecessary to maintain a separate genus for each of these species on trivial differences in the fruiting bodies, none of which are more than specific. The important generic characters, in common, are the limeless sporangia with refuse matter in the lower parts of the walls; the absence of a capillitium; and the more or less well-defined lids. They are close to *Licea*, differing in the manner of dehiscence.

O. operculata, as first proposed was stalked, but sessile sporangia have since been recorded. The mere presence or absence of stalks is not a generic character. *K. pusillus*, a similar sessile form, differs only in minor characters from *O. operculata*. Likewise with *H. parasitica*, but here we have the observations of Zukal about the unusual behavior of the swarm-cells and plasmodia in

cultivations of the form, and obviously, this was regarded as a generic character. Little is known about the early life history of the great majority of the recognized species of the Mycetozoa, and through later research we may find other species with a life history different from that assumed to be uniform for the group. *Hymenobolina pedicellata* Gilb. (Univ. Iowa Stud. Nat. Hist. **16**: 153. 1934) is said by the author to form a single sporangium from each small plasmodium, like *H. parasitica,* and has been doubtfully placed in the genus although the sporangia do not have lids. It is omitted from this proposal, as its position is not certain.

The results of culture experiments are subject to question until fully substantiated. This is shown in the expanding literature on the subject by the different results obtained by different investigators with the same species. When results do show an unusual life history, I cannot agree that this should be considered as defining or limiting generic boundaries. We should confine ourselves to the consistent classification based solely on the characters of the fruiting bodies, which is satisfactory and universally accepted. To make exceptions may in time lead to a classification based partly on a set of constant characters, and partly on another of questionable ones, with frequent changes and consequent confusion, as our knowledge of the early life history increases. Regarded in this light, the three species belong in one genus, *Orcadella,* the first proposed. They are fully represented in the Herbarium of the New York Botanical Garden by natural developments.

PERICHAENA CORTICALIS (Batsch) Rost. A few sporangia of var. *liceoides* (Rost.) List. were found on a mossy log at Wevertown, Warren County, New York, in August. They are small, .2 mm. diam., subglobose, somewhat iridescent, yellowish brown. The sporangial wall is single, membranous, translucent, yellow, without granular deposits, and finely and closely stippled or papillose. The capillitium is scanty, consisting of simple, thin, and almost smooth elaters. The spores are yellow, minutely and closely warted, 11 μ diam.

This specimen undoubtedly belongs in the genus *Perichaena,* and not in *Licea* or *Oligonema.* Its position in the genus is not so clear. These small sessile or stalked Perichaenas are found occasionally, and the trouble is not only that they are scarce and in

small fruitings, but they are not constant in characters and differ from descriptions. This is seen again in the present form, which, with its papillose wall resembles *P. vermicularis* (Schw.) Rost. For the time being, it is placed with *P. corticalis*. N. Y. B. G. No. *2470*.

PHYSARUM NUDUM Macbr. Any student of the Mycetozoa with sufficient field experience knows of the frequent occurrence of limeless forms in some of the calcareous genera. I have seen a number of such in *Physarum*, and occasionally in *Badhamia*, *Didymium* and *Diachea*. Sometimes they can be identified by the company of normal or partly normal sporangia, or the presence of some pronounced character. When this cannot be done, the specimens are thrown away here as worthless. To take one of them and place the stamp of a new species on it, simply because it is limeless and cannot be definitely placed, is absurd. *P. nudum* is merely a limeless phase of some species, perhaps a *Physarum* as the author believed, but not necessarily, and more likely, *Badhamia panicea* (Fries) Rost., as the clustered, angled sporangia, with reddish brown bases and stalks of the latter species are present. *B. panicea* occasionally has limeless sporangia associated with normal ones in the same colony. Unfortunately, there are too many species in the American literature based upon abnormal, erratic or imperfect developments. N. Y. B. G. No. *7379* (portion of cotype).

PHYSARUM PSITTACINUM Ditm. In August 1941, and on an earlier occasion in July 1938, we found developments of this species in Wayne County, Pennsylvania, which have stalks and bases of a tawny yellow color instead of the usual orange-red or vermilion of the typical form. The lime-knots in the capillitium are white, or hyaline and translucent, with only an occasional trace of pale yellow. The specimens are var. *fulvum* List. N. Y. B. G. Nos. *2590, 4891*.

PHYSARUM PUSILLUM (Berk. & Curt.) Lister. The typical phase of the species appeared in great abundance on nearly every compost or pile of decaying, vegetable rubbish examined in New York, Ontario, and Quebec, during the last days of August. These places are the best collecting grounds for the species, and when it appears, it seems to be everywhere. Usually, other interesting species are on the same piles. In the typical form the

sporangia are not globose, but always more or less flattened or concave beneath, and the stalks are reddish brown. The form is easily recognized by its superficial resemblance to *Didymium xanthopus* (Ditm.) Fries. Many specimens in the Herbarium of the New York Botanical Garden.

PHYSARUM SUPERBUM Hagelstein. Collected by Dr. Erdman West at Gainesville, Florida, in June 1940. N. Y. B. G. No. *9418*.

STEMONITIS CONFLUENS Cooke & Ellis. There are ten collections of the species in the Herbarium of the New York Botanical Garden. Three were made by J. B. Ellis, coauthor of the species, at Newfield, New Jersey, in 1880, 1881, and 1896; another by T. C. Palmer at Chester, Pennsylvania, in 1920; and the others by my associates and me on Long Island, New York, at various localities in 1933, 1935, 1936, and 1941. All the collections are remarkably uniform in appearance and characters. The fructifications, generally, are on the inner side of oak bark where it has sprung away from the trunk of the decaying tree, and appeared usually late in the season, October and November. The species must have a wider range of distribution and should be found elsewhere, as it is conspicuous when discovered, and easily recognized without the aid of a lens.

The plasmodium, when fruiting, divides into small portions, forming many small, almost black tufts of confluent sporangia, from 1 to 10 mm. across, rarely a little larger. The sporangia are 1 to 3 mm. high. The sporangia are usually free at the tops and bases, but connected at the middle by lateral extensions of the capillitia or nets, the extension threads carrying small, membranous discs, which are persistent remains of the otherwise weak peridia, consisting of agglutinated spores and vanishing rapidly after the sporangia have matured. The discs are characteristic of the species. The stalks are usually weak and tortuous, continuing into the sporangia as columellae, either to the tops, or merging into the capillitia. In small colonies, the stalks are sometimes combined so that the entire tuft rests upon a single, thick, compound stalk. The rigid, dark brown threads of the open capillitium merge at the surface into a wide-meshed net, usually complete at the top, but sometimes incomplete at the base. The spores are purplish brown, minutely but distinctly spinulose, 11–12 μ diam.

The Ellis form is clearly described in the Myxomycetes by Macbride and Martin, and in the North American Slime-Moulds by Macbride. It has not been treated properly in the British Monographs, but this is understandable, as formerly the form was known only from the collections of Ellis. In the first edition, it was regarded as a confluent form of *Stemonitis splendens* Rost., and, while recognized as a species, the idea was continued through the following editions by the remark that it may possibly be a confluent form of *S. splendens*. In the description there is no mention of the dark, almost black color of the colonies, nor of the membranous discs. It says further that the colonies are often several inches across. The spore-size is given as 8–11 μ diam. The description, without a figure, is too broad, and conveys an impression that it is intended to include other forms which occasionally have confluent sporangia. This is shown by several specimens in the herbarium here, determined by a capable student, which have absolutely no relationship to the form of Ellis, but were placed therewith apparently, because the sporangia are somewhat confluent. The sporangia in these forms are large, brown in color, and have spores measuring about 9 μ. They are clearly erratic or abnormal forms of something else, perhaps *S. splendens*.

Erratic or abnormal phases are common enough in *S. splendens* and other species of *Stemonitis*. When the sporangia are confluent, and other characters are not clearly those of another species, the inclination is to place them with *S. confluens* under the Lister description. This should not be done unless the other characters of the Ellis form are present. Briefly, these are the small colonies, almost black in color; the persistent peridial discs; and the large spinulose spores. They are constant in all specimens here, and combined, distinguish *S. confluens* from every other species of *Stemonitis*.

TUBIFERA STIPITATA (Berk. & Rav.) Macbr. A curious form of this species has come here from Dr. Erdman West, collected at Gainesville, Florida, in September 1938. There are five aethalia of clustered sporangia on long, stout stalks, one of which is 5 mm. high. Among the aethalia are many single sporangia on long, dark, thin, flattened stalks, a stalk for each sporangium. N. Y. B. G. No. *8893*.

THE NEW YORK BOTANICAL GARDEN

MYCOLOGICAL NOTES. VI

C. L. Shear

23. Sphaeria pyriformis Pers. Syn. Fung. 64. 1801

Persoon described this *Sphaeria* as follows:

125. *Sphaeria pyriformis:* sparsa minuta simplex, sphaerulis pyriformi-conicis, ostiolis acutis confluentibus.

Prov. rarius ad ligna exsiccata

Obs. Quoad formam quadantenus cum *Sphaeria subulata* Tode t. 15 f. 117. c congruit, sed basi latior; colore quoque differt, nec non superficie laevi.

It is evident that this description is insufficient for the identification of the plant. One can not be sure whether it is an ascogenous or imperfect form. The application of the name, if it is to be retained, must be determined by type or authentic specimens or its application by subsequent authors. We found 3 specimens so labelled in Persoon's Herbarium at Leiden. All have a question mark. We have had opportunity to examine only one of these microscopically. This was collected by Chaillet in Switzerland and agrees very well with Persoon's description. Microscopic study shows it to be a species of *Camarosporium*, having spores 21–30 × 12–16 μ, agreeing well with *C. sarmenticium* Sacc.

Fries (Syst. Myc. **2**: 539. 1823) transferred what he supposed to be Persoon's species to *Sphaeronema* with the following description:

10. *S. pyriforme*, peritheciis late conicis acutis laevibus, globulo ovali deciduo aterrimo.

S. pyriformis Pers. Syn. p. 64 (Scler. Suec. n. 274).

Sparsum l. gregarium, pusillum, opacum, aterrimum, glaberrimum, basi dilatata adnatum, globulo semper opaco. *In ligno exsiccato Quercus.* Aut.-vere. (v.v.).

The specimen in his exsiccati cited (Scler. Suec. No. *274*) apparently included more than one species. Jaczewski (Nouv. Mém. Soc. Natur. Moscow **15**: 358. 1898) says the specimen of this number he examined was *Dendrophoma pleurospora* Sacc. Von.

Höhnel (Sitz.-ber. Akad. Wien **122**: 286–287. 1913) says the specimen of Fries *274* he examined bore only a species of *Rhamphora* which he calls *R. pyrenophora* (Fries) Höhnel, but says it is doubtful whether it is different from *R. tympanidispora* Rehm and *R. thelocarpoidea* Höhnel. Unfortunately we have been unable to examine a specimen of this number.

Schweinitz (Trans. Am. Phil. Soc. II. **4**: 247. no. *2139*. 1832) reports *Sphaeronema pyriforme* Fries with note "Sub cortice Pyri, Bethl. in libro." A part of his specimen in the Michener herbarium is typical *Rosellinia pulveracea* (Ehrh.) Fuckel.

This name appears in Saccardo (Syll. Fung. **3**: 191. 1884) as *Sphaeronema piriforme* Pers. with a copy of Fries' description as given above.

In view of the uncertainty and confusion concerning the proper application of this name it would seem best to drop it for the present at least.

24. SPHAERIA HEMISPHAERICA Alb. & Schw.

Albertini and Schweinitz described *Sphaeria hemisphaerica* (Consp. Fung. 51. *pl. 8, f. 8*. 1805) on decorticated *Fagus*. Saccardo (Syll. Fung. **3**: 170. 1884) referred it to *Aposphaeria?* Later (Syll. Fung. **10**: 397. 1892) he gives it as *Collonema hemisphaericum* (Alb. & Schw.) Grove, in litt. Grove does not mention this species (British Stem & Leaf Fungi **1**: 446. 1935) and we do not know on what specimens he based his opinion that it belonged to his genus *Collonema* which has long fusoid spores, unless it be from Fuckel (Symb. Myc. 400. 1869) where the latter lists *Sphaeronema hemisphericum* Fries and says *Spermatiis filiformibus*. Fuckel cites no specimens, but his description certainly does not apply to either Albertini & Schweinitz' or Fries' plants. Grove based his genus *Collonema* on *C. papillatum* Grove (Jour. Bot. **24**: 136. *pl. 266, f. 5*. 1886). According to Saccardo (Syll. Fung. **10**: 297. 1892) *Oncosporella* Karst. is a synonym of *Collonema*.

There is a specimen labelled simply *"Sphaeria hemisphaerica* Alb. & Schw. Germany" in Persoon's herbarium. This may have been sent him by Albertini and Schweinitz or collected by Persoon

himself. The specimen is on beech. The pycnidia are dimidiate with a plane ostiole and similar in appearance to the perithecia of *Zignoella*, Section *Trematostoma* Sacc. as typified by *Z. Morthieri*. The spores are 4–5 × 3 μ, hyaline, firmly agglutinate, yellowish in mass. No sporophores were seen. This fungus is evidently not congeneric with Grove's type of *Collonema* (*C. papillatum*), which has complete, subglobose pycnidia with a papilliform ostiole and fusoid spores, 18–19 × 2.5 μ.

The Persoon specimen is very similar to *Aposphaeria subtile* (Fries) Sacc. as found in Michener's specimen No. *2900* mentioned below and associated with perithecia of *Zignoella*.

Fries described as *Sphaeronema hemisphericum* in Kunze & Schmidt (Myc. Hefte **2**: 57. 1923) and later the same year (Syst. Myc. **2**: 539. 1923) what he regarded as Albertini and Schweinitz' species and issued specimens in his Scler. Suec. No. *104*. Fries' fungus was on pine, and according to several specimens of his number *104* examined, it is a *Zignoella*, which was later described by Fuckel as *Trematosphaeria Morthieri*. Jaczewski (Nouv. Mém. Soc. Natur. Moscow **15**: 334. 1898) says he also found the same species on the specimen of Fries' No. *104* which he examined. We find no discussion of this species by von Höhnel. Grove and Saccardo regard certain species of *Aposphaeria* as pycnidial stages of *Zignoella*.

Assuming that the *Sphaeria hemisphaerica* of Albertini & Schweinitz is the fungus described above from Persoon's Herbarium, it is clear that it is not the plant to which Saccardo, Grove and Fries applied the name, but a pycnidial form for which we have thus far found no satisfactory generic or specific name. It may perhaps for the present as well be left in *Aposphaeria*, as in the case of *Sphaeronema subtile* discussed below, until more complete information can be obtained.

25. SPHAERONAEMA SUBTILE Fries in Kunze & Schmidt, Myc. Hefte **2**: 57. 1823

This species was distributed by Fries in his Scleromycetes Sueciae No. *160* on *ligna mucida*. Jaczewski (Nouv. Mém. Soc. Natur. Moscow **15**: 353. 1898) examined a specimen of this

number, and found pycnidia, small, superficial, globose, ostiolate, with spores ellipsoid, hyaline. No measurements are given. On a specimen of Fries' No. *160,* 1st edition, in Michener's Herbarium from Schweinitz, we find minute, superficial, thin walled, black pycnidia on bleached decorticated, frondose wood, having a slightly yellowish agglutinated spore mass; spores somewhat inequilateral, 4–5 × 1.5–2 μ. This is apparently the same as the specimen Jaczewski had. Another specimen of this number from the 2nd edition of Scler. Suec. appears to be the same, but has slightly smaller spores 3 × 1.5, apparently not quite mature. This would naturally be referred to *Aposphaeria* except for the light colored spores. A specimen apparently identical with Fries' No. *160* found in Michener's herbarium as No. *2900,* collected in Pennsylvania and determined as *S. subtile* by Curtis, has associated with the pycnidia good perithecia of a *Zignoella,* very close to *Z. diaphana* Cooke & Ellis, which may be the perfect stage of this pycnidial form.

Fries' original description (l. c.) says *ad ligna mucida.* No host is given. The specimen of his No. *160* described above agrees entirely with his original description. In Syst. Myc. **2**: 539. 1923, he gives a fuller description and *Sorbus, Corylus,* etc. are given as hosts. Jaczewski refers Fries' plant to *Aposphaeria* as *A. subtilis* (Fries) Sacc. (Syll. Fung. **3**: 171. 1884). Von Höhnel has no note on this species. Bonordon applied this name to an entirely different fungus, *Phoma acuta* Fuckel on *Urtica,* according to Jaczewski (l. c. 343). Fries' species referred to *Aposphaeria* by Saccardo is very closely related if not the same as *Sphaeria hemisphaerica* Alb. & Schw., but neither is a true *Aposphaeria,* either as applied by Berkeley or Saccardo, as already stated. They may be left there, however, until a more satisfactory generic name can be found. As the result of our studies of this material we conclude that *Sphaeronema subtile* Fries is *Aposphaeria subtile* (Fries) Sacc., but not a true *Aposphaeria,* as the pycnidia of this fungus are dimidiate, the basal portion of the pycnidial wall is lacking and the conidia develop from a thin, hyaline sporogenous layer in the wood of the matrix. This is a form intermediate between the true pycnidia of Phomaceae and the dimidiate pycnidia of the Leptostromaceae.

Aposphaeria Berk. as usually applied has complete pycnidia and can scarcely be distinguished from *Phoma* as used by Saccardo. In fact, both of the species originally referred by Berkeley to his genus, *A. acuta* and *A. complanata*, are transferred to *Phoma* by Saccardo, and another species, *Phoma pulviscula* Sacc., cited as an example of his concept of *Aposphaeria* (Michelia **2**: 4. 1882). As indicated in note 24 above, *Sphaeria hemisphaerica* Alb. & Schw., according to the specimen in Persoon's herbarium, which we believe to be the fungus described by Albertini and Schweinitz and possibly an authentic specimen from them, has the same dimidiate pycnidia so aptly characterized by the specific name.

The *Sphaeronema hemisphaericum* of Fries is not the plant described as *Sphaeria hemisphaericum* by Albertini and Schweinitz, but may be the perithecial stage of that fungus. Fries' plant is the same as *Zignoella Morthieri* (Fuckel) Sacc.

26. ODONTOTREMA Nyl. Not. Sällsk. Faun. Fl. Fenn. Förhand. V. **2**: 249. 1861

This genus was described as follows:

II. ODONTOTREMA Nyl.

Thallus vix ullus distinctus. Apothecia nigra thelotremoideo-lecideina (vel gymnotremoidea) nuda, primo clausa, dein margine (proprio) denticulato-rupto dehiscentia. Forte potius Fungis relegandum genus.

1. *O. minus* Nyl. *Herb. Mus. Fenn.* 91. 1859.

Thallus macula saepe valde dilatata albida vel albido-cinerascente indicatus (vix ullus verus); apothecia sat sparsa parva (vix 0,5 millim. latiora); sporae incolores ellipsoideae simplices, interdum tenuiter 3-septatae, longit. 0,011–15, crassit. 0,006–7 millim., paraphyses graciles. Gelatina hymenea iodo vinose rubens.

Supra lignum abietinum vetustum ad Helsingfors raro; prope Aboam (P. A. Karsten); prope Kajanam (K. P. Malmgren).

Huic generi accedit *Schizoxylon* Pers., tres in Europa offerens species (omnes thecis seriatim polysporis), scilicet *Sch. saepincolam* Pers., *Sch. corticolam* ("Coniangium corticolam" Fr. S. V. Sc. p. 121, "Lecideam dryinam" Fr. L. S. exs. 273) et *Sch. dryinum* (Flk. D. L. 141 sub nomine "Lecidea dryina"). Ex iis modo *Schizoxylon corticola* e Scandinavia mihi cognitum, differens sporis minoribus (latit. et longit. circa 0,0025 millim.) a *Sch. dryino* (in quo sporae long. 0,009–0,012, crass. circa 0,0025 millim.). Sed potius fungis adscribendae sint hae species quam lichenibus."

Butler (Mycologia **32**: 811. 1940) says *Patellaria minor* Karst.

(Myc. Fenn. **1**: 233. 1871) is a synonym. We have been unable to verify this.

Von Höhnel (Ann. Myc. **15**: 306. 1917) discusses the type species, *O. minus,* and gives a description, but does not say on what specimens it was based. He states that the fungus arises in the outer woody fibers of gray wood and has a dark brown excipulum 20–30 μ thick at the base to 60 μ at the margin; hypothecium hyaline, 6–8 μ thick. Epithecium none. The cover opens with very regular teeth and bears on the under side a "quellschicht" or swelling layer. The ascus layer is plano-concave and sharply divided from the cover at the margin. He says it should go in the Phacidiales, in which opinion we concur, after comparing it carefully with *Phacidium lacerum* Fries which has the same peculiar structure of the cover; the swelling layer being made up of parallel hyphae arranged vertically.

Nannfeldt does not agree with von Höhnel and doubts his opinion that the cover of the fungus has a swelling layer which absorbs moisture and causes it to spread and rupture. We note, however, that in a closely related species we have found on *Zea Mays* and which is apparently unnamed there is the same structure, and that the layer of vertically parallel hyphae on the under side of the cover does function exactly as stated by von Höhnel. Sections of dried specimens show these hyphae to be thin, parallel and uniform in size. After soaking in water for 5 minutes they become much enlarged and clavate at the lower end, thus causing the cover to burst open and the segments to turn backward. In young specimens, when the asci are beginning to develop, the interior of the apothecium is found to consist of a continuous layer of parallel hyphae which extends from the very thin hypothecium to the inner surface of the cover. As the fungus develops the outer ends of these hyphae become very dark colored. As the asci develop and mature the layer of parallel hyphae ruptures transversely just above the ends of the asci and the lower portions remain as paraphyses, producing short irregular branches which form a very thin, light flesh colored epithecium.

We have seen no authentic specimens of Nylander's species but specimens distributed under No. *368* by Rehm in his Ascomyceten Exsiccati as *O. minus* Nyl. with a question mark, on bare wood of

Larix europaea in the Tyrol in August 1876, agree entirely with the original description and also with that of von Höhnel. The spores are hyaline, 1–3 septate, 9–13 × 4–5 μ. The characteristic swelling layer is present in the cover.

Von Höhnel (l. c.) discusses 7 other species which have been included in *Odontotrema* and decides that none of them is congeneric with the type, *O. minus*. If we accept von Höhnel's account of the type and the presence of a swelling layer in the cover of the apothecium as one of its essential characters many of the other species now included will probably be found to belong elsewhere. This can not be positively determined until the presence or absence of the swelling layer in each is decided.

Sphaeropezia would become a synonym of *Odontotrema* if the type of the genus which has not been seen by von Höhnel or others should be found to possess a "quellschicht," as no other character of generic value is described. *S. Arundinariae* Cash (Jour. Wash. Acad. Sci. **30**: 300. 1940) has a typical "quellschicht" as does the apparently undescribed species of *Odontotrema* on *Zea Mays* mentioned above. Single ascospore cultures of this latter form never produced spores of any kind on cornmeal agar.

27. ODONTOTREMA HEMISPHAERICUM (Fries?) Rehm

This is supposed to be *Stictis hemisphaerica* of Fries (Syst. Myc. **2**: 196. 1822) which he says occurs on "pine &c." He lists it also in Summa Veg. Scand. 373. 1849, but no specimens are cited in either place. In the description of the genus he describes the spores as "vulgo uniseptat." It is not to be inferred from this that he had examined the spores of this particular species, as he lists ten, of which his *S. hemisphaerica* is the second.

Von Höhnel (Ann. Myc. **15**: 308. 1917) says this species is entirely (völlig) different from Nylander's type of *Odontotrema*, and makes it the type of a new genus *Xylopezia*. He based this conclusion upon an examination of a specimen of Fuckel's *Xylographa hemisphaeria* (Fries) in Fung. Rhen. Ex. No. *2673*, which he says shows great similarity to *O. minus*, but does not belong to the same genus. He does not state whether he found any "quellschicht" in this specimen or not. Unfortunately, we have seen no

specimen of Fuckel's No. *2673*. There is, however, a specimen from Fuckel's herbarium at Geneva, No. *1099* on *Pinus Cembra*, collected by him at Johannesburg, Switzerland, and originally referred to by him (Symb. Myc. Nachtr. *3*: 27. 1875), as *Xylographa hemisphaerica* (Fries). The specimen of this number in the Mycological Collections of the Bureau of Plant Industry, shows mostly *Xylographa parallela*. There are, however, a few young ascocarps of his *X. hemisphaerica*, but only immature nonseptate ascospores could be found. The young ascocarps have the same structure and appearance as described by von Höhnel, but no "quellschicht" was found.

Rehm distributed in his Ascomycetes Exsiccati No. *286* as *Trematosphaeria excellens* Rehm n. sp. two collections: (1) on decaying "fichten" (*Picea excelsa*) gathered in the Bavarian Alps by Arnold; (2) on decaying trunks of *Pinus Cembra* in the Tyrol, collected by himself. Both of these specimens lack the swelling layer found in the cover of typical *Odontotrema*, and are referred by von Höhnel to his new genus *Xylopezia*. No. 1 has spores hyaline, 1–3 septate, 10–12 × 4–5 μ; No. 2 has spores identical in shape and appearance, but only 8–10 × 3–4 μ. The latter specimen does not seem to be quite mature, as free spores were difficult to obtain, and that may account for the difference in size of the spores. Later Rehm cites these specimens of *T. excellens*, No. *286*, 1 and 2, as typical *O. hemisphaericum* with the following synonymy:

ODONTOTREMA HEMISPHAERICUM (Fries) Rehm, Krypt.-Fl. Deutsch. II. 1[3]: 205. 1888.

Stictis hemisphaerica Fries, Syst. Myc. **2**: 196. 1822.

Xylographa hemisphaerica Fuckel, Symb. Myc. Nachtr. **3**: 27. 1875.

Winteria excellens Rehm, Ber. Nat. Ver. Augsb. **26**: 72. 1881.

Zignoella excellens Sacc. Michelia **1**: 347. 1878.

Exsicc.: Fuckel, Fungi Rhen. No. *2673*, Rehm, Ascom. No. *286*.

Rehm states in a note following his description that he agrees with Fuckel in believing that this is the plant Fries described although only 1-celled spores are mentioned, which is often the case

in immature specimens. He says it is not a Pyrenomycete, as Winter states, but only simulates one before it is mature and that the species is very close to *Odontotrema minus*, but is distinguished by being finally erumpent and having larger apothecia, and it would be possible to think of them as belonging together. The erumpent or superficial appearance seems to be due to age and weathering of the substratum. The apothecia are rather variable in size in the same specimen. Von Höhnel (Sitz.-ber. Akad. Wien **118**: 1209. 1909) says that *Zignoella excellens* (Rehm) Sacc. is only a form of *Odontotrema hemisphaericum* (Fries) Rehm. Nannfeldt (Morph. Syst. Disc. 212. 1932) says *Odontotrema* Nyl. (type *O. minus*) does not belong to the Phacidiaceae. Fries cites no specimen of his species in Systema Mycologicum Summa Vegetabilium Scandinaviae, p. 373, and unless authentic specimens can be found Fuckel's specimens cited above may be accepted as representing the species.

The life cycle and morphology of this and related species need thorough study in order to determine their exact generic character and relationships. Two or three species have been collected on decorticated, coniferous wood and also on *Salix* and *Populus* in subalpine localities of Colorado, but their specific identity is somewhat doubtful.

28. CLYPEOTHECIUM Petr.

This was described by Petrak (Ann. Myc. **20**: 192. 1922) with the monotype *C. Weirii* Petr. The type specimen is J. R. Weir's No. *16638* on cedar (*Thuja plicata*) collected at Kooskia, Idaho, May 29, 1920. Weir's No. *16610* on *Abies grandis*, from Orofino, Idaho, is also cited. There is abundant material of both these numbers in the Mycological Collections of the Bureau of Plant Industry, as well as Weir No. *16665* on *T. plicata* from Clearwater, Ida., and Weir No. *16605* on *A. grandis*. A study of these specimens shows that they are all *Zignoella Morthieri* (Fuckel) Sacc., which is a rather variable species, especially in size of perithecia and size and septation of spores. The ascocarps are described as single perithecia each covered with a clypeate stroma. Their superficial appearance is that of a depressed subglobose or elliptical peri-

thecium on the surface of decorticated wood. A vertical section shows that it is dimidiate, the ascogenous layer at the base having no distinct wall.

This is not a true *Zignoella* as described by Saccardo (Michelia **1**: 346. 1878). He divided the genus into 2 sections, the first with 19 species (3 doubtful) and the second with 8 species. As the type we have chosen *Z. pulviscula* (Curr.) Sacc., which is the second species in the section *Eu-zignoella* of Saccardo (Syll. Fung. **2**: 214. 1883) and one of the best known species. This has complete separate perithecia and is quite different from *Z. Morthieri,* which was placed in a subgenus, *Trematostoma* (Sacc. Syll. Fung. **2**: 222. 1883) and may be regarded as typical. It is unfortunate that Petrak did not recognize that the Weir specimens were congeneric with Saccardo's subgenus *Trematostoma* and raise it to generic rank, instead of making a new name. According to present rules, subgeneric names do not have priority and in order to adopt *Trematostoma* which is the preferable name, we propose that it be given generic rank and conserved with **T. Morthieri** (Fuckel) Shear, comb. nov. as its type.

It is evident from the structure of this plant that it is not a true member of the Sphaeriaceae. Petrak (Ann. Myc. **21**: 281. 1923) says it is near *Melomastia* having a dothideaceous structure nearly related to the Pleosporaceae. Much more knowledge of the life cycles and morphology of this and related genera is necessary before any satisfactory family distinctions can be drawn.

Most of the species of *Zignoella* referred by Saccardo to his subgenus *Trematostoma* are very similar, and some of them are known to be synonymous. The type, *Z. Morthieri,* is usually found on decorticated and bleached wood of coniferous trees. The perithecia and spores are variable in size, shape and septation, depending on their age and condition of development. A specimen in Thüm. Myc. Univ. Exs. No. *167* gathered by Morthier in Switzerland on *Abies* in 1875 has hyaline, 3-septate spores, 22–25 × 6–8 μ. Berlese (Icon. **1**: 98. 1894) gives 24–27 × 7–8 μ and says *Sphaeria albocincta* Cooke & Ellis, according to authentic specimens, is the same. Von Höhnel (Mitt. Bot. Inst. Tech. Hch. Wien **4**: 44–46. 1927) examined a specimen of this in Ellis and Everhart's North American Fungi No. *1198,* and also says it is

the same as *T. Morthieri*. *Sphaeria diaphana* Cooke & Ellis Grevillea **5**: 53. 1876, according to an authentic specimen we have examined, differs only in slightly smaller ascospores 18–20 × 6–7 μ. The spores in *T. Weirii* according to Petrak are 22–30 × 6–10 μ. The extremes here are slightly larger than usual in *T. Morthieri*. *Zignoella soluta* (Cooke & Ellis) Sacc., with spores 17–20 × 6–7 μ can scarcely be more than a mere form of the same species.

The synonymy according to our present information is as follows:

Trematostoma Morthieri (Fuckel) Shear, comb. nov.

Trematosphaeria picastra Fuckel, Symb. Myc. 162. 1869? non Fries.

Trematosphaeria Morthieri Fuckel, Symb. Myc. Nacht. **1**: 306. 1871.

Leptosphaeria picastra Fuckel ex Höhnel. Mitt. Bot. Inst. Techn. Hoch. Wien **4**: 44. 1927.

Sphaeria diaphana Cooke & Ellis, Grevillea **5**: 53. *pl. 80, f. 15.* 1876.

Sphaeria albocincta Cooke & Ellis, Grevillea **7**: 9. 1878.

Sphaeria soluta Cooke & Ellis, Grevillea **5**: 54. *pl. 80, f. 16.* 1876 (as "solutae").

Zignoella albocincta (Cooke & Ellis) Sacc. Syll. Fung. **2**: 224. 1883.

Zignoella diaphana (Cooke & Ellis) Sacc. Syll. Fung. **2**: 220. 1883.

Zignoella soluta (Cooke & Ellis) Sacc. Syll. Fung. **2**: 216. 1883.

Zignoella Morthieri (Fuckel) Sacc. Michelia **1**: 347. 1878.

Clypeothecium Weirii Petrak, Ann. Myc. **20**: 182. 1922.

Other closely related species are *Zignoella minutissima* (Karst.) Sacc., *Z. jurana* Sacc. & Berl., *Z. translucens* Karst., and *Z. minutissima* subsp. *clavispora* Karst. Some of these are apparently synonymous according to the descriptions, but must await the study of authentic specimens for final decision.

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NEW SPECIES OF ACAULOPAGE AND COCHLONEMA DESTRUCTIVE TO SOIL AMOEBAE

CHARLES DRECHSLER

(WITH 6 FIGURES)

In continuation of observations on biotic relationships of soil microörganisms often revealed in agar plate cultures that after being well permeated with oömycetous mycelium have received some addition of decaying vegetable material, 3 conidial Phycomycetes apparently not hitherto described have been found destroying particular species of terricolous amoebae. Two of the phycomycetous forms are presented herein as new members of the predaceous genus *Acaulopage*, while the third is set forth as a new member of the parasitic genus *Cochlonema*. Further, a rather pronounced morphological variant of *C. bactrosporum* Drechsl. (**5**) is described as a new variety of that species; and occasion is taken to report supplementary findings pertaining to the vegetative stage of *Acaulopage tetraceros* Drechsl. (**2**), and to the asexual reproductive stage of *Stylopage cephalote* Drechsl. (**4**).

A SPECIES OF ACAULOPAGE PRODUCING CONIDIA BESET WITH STUBBLY APPENDAGES

Several maizemeal-agar plate cultures that after being permeated with mycelium of *Pythium splendens* Braun had been planted with small quantities of leaf mold collected near Beltsville, Md., early in January 1941, showed on cursory examination four weeks later scattered conidia bristling with stubbly appendages. In their scant distribution on the surface of the medium, as well as in their unusual ornamentation, the spores bore a suggestive resemblance to the conidia of *Acaulopage acanthospora* Drechsl. (**4**). It was not surprising, therefore, that on closer scrutiny they were found to arise from a sparse unseptate mycelium to which were attached

here and there specimens of a naked rhizopod undergoing expropriation of protoplasmic contents.

The rhizopod which thus served the sparse mycelium as food supply, apparently to the exclusion of other nourishment, varied in width between 10 μ and 40 μ when drawn into a somewhat rounded shape. When moderately extended the larger individuals often measured between 50 μ and 55 μ in length. Some, though not all, of the newly captured animals revealed from 5 to 10 vacuoles, which from their successive enlargement and contraction appeared to operate as contractile vacuoles (FIG. 1, *A*). Occasionally a few rather small subspherical bodies could be distinguished within an animal, but more frequently no structure having any similarity to a protozoan nucleus was recognizable in the peculiarly turbid, almost opaque, very finely and densely granular, yellowish protoplasm. In newly captured prey, whose normal structure had not yet been noticeably affected, a pellicle could hardly be made out, though the presence of a somewhat firm enveloping membrane was indirectly betrayed through the adhesion of the animal to one or more minute deposits of yellow substance secreted by the hypha. The haustorial system which soon came to be extended inward from each place of adhesion likewise was at first either indiscernible or only faintly discernible (FIG. 1, *A; B; C, a, b; D*). However, as the contents of the prey became more and more attenuated, the haustorial system emerged with increasing clearness, and surrounding it the pellicle became visible as a faint contour (FIG. 1, *E, a, b; F, a, b; G; H; I*). With respect to branching habit the haustorial system was essentially of the rangy arbuscular type, but owing to unusually prolonged extension of the assimilative branches in the more distant portion of the animal these branches converged and overlapped distally in such manner that in profile they presented a characteristic intertangled appearance alien to the haustoria of any predaceous fungus yet described. Once the animal's protoplasm had been completely absorbed, the protoplasm of the haustorial system was withdrawn backward into the parent filament, and soon all vestiges of the rhizopod and of the ramifying apparatus that encompassed its destruction were lost to view.

The fungus initiated asexual reproduction by giving rise here and there to relatively short hyphal branches, each of which became

enlarged terminally to form a subspherical body on the surface of the culture medium. During its growth this body remained smooth (FIG. 1, *J–P*), but after attaining definitive size it put forth numerous digitate protuberances from all portions of its surface exposed to the air. Naturally these protuberances while actively elongating contained protoplasm (FIG. 1, *Q*), which, however, was promptly withdrawn when elongation came to an end (FIG. 1, *R, a, b; S*). A septum was now laid down in the short supporting branch to delimit the spherical body as a conidium. Evacuation of a short stalk-like part above the septum occasionally left the spore with a small empty basal appendage (FIG. 1, *T*), but much more often the proximal end was marked only by a pedicellate protrusion (FIG. 1, *U; V, a–g*).

Despite obvious similarities, the conidia thus formed differ conspicuously from those of *Acaulopage acanthospora*. In the present fungus the empty appendages, instead of tapering perceptibly, maintain a virtually uniform width from base to blunt apex. When the spore is viewed laterally the number of digitations directly visible in upper aspect and in profile varies commonly from about 15 (FIG. 1, *R, a*) to about 75 (FIG. 1, *V, d*); wherefore the total number, including those concealed underneath, probably ranges from 25 to 125, rather than from 7 to 18 as in *A. acanthospora*. Again, in the present fungus the digitations sometimes are distributed only over a distal region of limited extent, and at other times are distributed over the entire surface of the conidium; whereas the tapering appendages of *A. acanthospora* are distributed more constantly over the distal hemisphere of the spore. The fungus predaceous on the yellowish amoeba undoubtedly represents a separate species, which according will be described as new under a name meaning in part "rough" or "shaggy."

Acaulopage lasiospora sp. nov.

Mycelium sparsum, parce ramosum; hyphis incoloratis, aliquantum flexuosis, .9–1.4 μ crassis, ad animalia minuta inhaerentibus, pelliculam cujusque capti perforantibus, haustorium (subinde 2 vel 3 haustoria) intus evolventibus quod protoplasma exhaurit; haustorio ex 2–15 ramulis 10–50 μ longis, 1–1.3 μ crassis, saepius recurvis et inter se intricatis constante. Ramuli fertiles saepius 5–40 μ longi, interdum repentes, conidia singulatim super materiam subjacentem ferentes; conidiis hyalinis, saepe aliquantum pedicellatis,

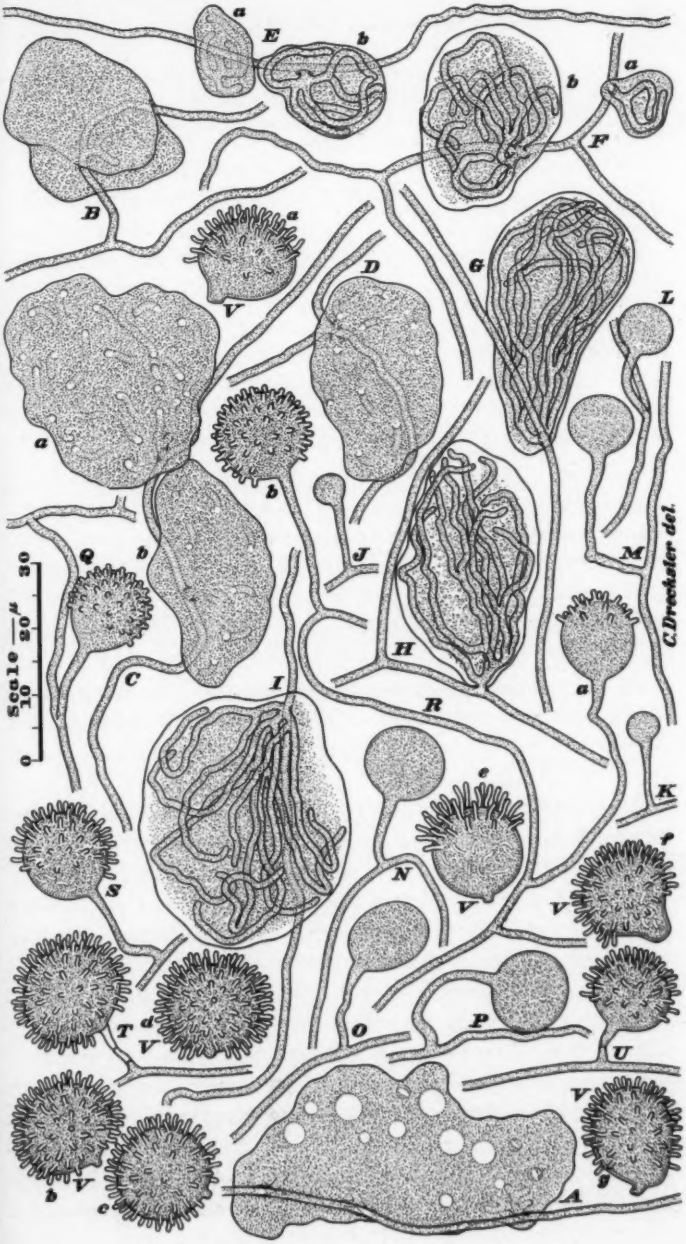

FIG. 1. *Acaulopage lasiospora.*

quoque ex cellula viventi et 25–125 appendicibus vacuis constante; cellula viventi globosa vel aliquid applanata, plerumque 12–16 μ longa, 11–16 μ lata; appendicibus 1.5–4 μ (plerumque circa 2 μ) longis, .6–.7 μ crassis, cylindratis, rectis vel leniter curvatis, apice abtusis vel truncatis, nunc ubique circum cellulam viventem nunc tantummodo in parte supera ejusdem positis.

Amoebas flavidas vulgo 10–40 latas capiens consumensque habitat in humo silvestri prope Beltsville, Maryland.

Mycelium sparse, sparingly branched; vegetative hyphae colorless, somewhat flexuous, .9 to 1.4 μ wide, capturing minute animals through adhesion, perforating the pellicle of each captive, and extending into it a haustorium (or sometimes 2 or 3 haustoria) to appropriate the protoplasmic contents; haustorium bush-like, with 2 to 15 branches, which vary from 10 to 50 μ in length and from 1 to 1.3 μ in width, and which often recurve distally to appear as if intertangled. Fertile branches often 5 to 40 μ long, sometimes prostrate, each bearing terminally a single conidium on the surface of the substratum; conidium hyaline, consisting of a living cell densely filled with protoplasm, subspherical or often oblate ellipsoidal in shape, mostly 12 to 16 μ long and 11 to 16 μ wide, usually somewhat pedicellate at the base, beset everywhere or sometimes only in its distal portion with empty digitate appendages; the latter from 25 to 125 in number, 1.5 to 4 μ (mostly about 2 μ) long, .6 to .7 μ wide, cylindrical or slightly curved, obtuse or tuncate at the tip.

Capturing and consuming amoebae yellowish in color and commonly 10 to 40 μ wide, it occurs in leaf mold near Beltsville, Md.

A SPECIES OF ACAULOPAGE WITH LATERAL CONJUGATION

An agar plate culture which after being permeated with *Pythium* mycelium had received some addition of decaying grass detritus gathered near Beltsville, Md., early in January 1941, showed on microscopic inspection 24 days later numerous slender erect conidia provided individually with a withered distal appendage—the bristling display offering general similarity to a sporulating tract of *Acaulopage rhicnospora* Drechsl. (2). However, the mycelium from which the conidia arose (FIG. 2, *A–F*) was noticeably coarser than that of *A. rhicnospora*, although the hyphae composing it tapered to widths of only .6 μ or .7 μ in their terminal portions (FIG. 2, *G*). These hyphae subsisted, apparently to the exclusion of other nourishment, on amoebae varying from 10 to 40 μ in diameter when drawn into an approximately round shape; the protozoans being captured through adhesion to minute deposits of a

yellow substance. Owing to turbidity normal to the animal's sarcode, details of nuclear structure could not be made out in newly captured specimens. After its invasion by a haustorium bearing on a narrow stalk several wider digitate branches, and consequent to the ensuing depletion of its protoplasmic materials, the captive usually came to reveal internally a prolate ellipsoidal structure containing 3 to 6 bodies in peripheral positions (FIG. 2, *A, n; B, n; C, n; D, n; E, an, bn*). This structure probably represented the animal's nucleus, perhaps modified in some degree by incipient pathological changes, though its continued functional capacity was manifested in prolonged operation of the contractile vacuole (FIG. 2, *A, v; B, v; C, v; D, v; E, av, bv; F*). Later the structure disintegrated, and its materials together with remnants of cytoplasm were assimilated by the fungus. Thereupon the contents of the haustorium were withdrawn into the parent hypha; and the empty haustorial membrane, as well as the collapsed pellicle surrounding it, was soon lost to view.

Development of asexual spores was initiated by the production of erect aerial processes from the mycelial hyphae extended on the surface of the culture medium (FIG. 2, *G–I*). On reaching full stature (FIG. 2, *J, a*) the individual process showed noticeable constriction about 1 μ above its origin, and farther upward, approximately midway between base and tip, it tapered into a delicate awl-like prolongation. Through retraction of contents from the attenuated distal part, and deposition of a cross-wall at the basal constriction (FIG. 2, *J, b*), a terminally appendaged conidium came into being at the tip of a short tapering sterigma. On exposure to moderately dry air the empty appendage soon shriveled, much like the similar appendages of various other zoöpagaceous forms (FIG. 2, *K, a–v*). As a general rule the cylindrical or somewhat fusiform living cell of the conidium tapered less markedly toward the base than in *Acaulopage rhicnospora,* and accordingly was somewhat more blunt at the proximal end.

Sexual reproduction took place simultaneously with asexual reproduction. Zygospores were formed in branches (FIG. 2, *C, b; L; M; N; O, a–c; P; Q; R*), which when relatively short—between 15 μ and 25 μ in length—were usually a little wider throughout than the parent filament (FIG. 2, *O, a, c*). When the branches

were longer such widening was evident only in a terminal portion, often measuring about 15 to 25 μ in length. At a stage when differentiation with respect to width first became noticeable, a cross-wall was laid down well toward the proximal limit of the swollen part, and a process grew out, sometimes from a position immediately above the septum (FIG. 2, *L*), sometimes from a position a few microns farther toward the tip (FIG. 2, *M*). The process, apparently, would then arch backward somewhat after the manner of clamp-connections in the basidiomycetes, and effect a junction with the parent branch just below the septum (FIG. 2, *N*). Soon after anastomosis was accomplished, if not at an earlier stage, a second cross-wall would be laid down to delimit a proximal gametangium frequently only one-half or one-third as long as the distal gametangium cut off by the first cross-wall (FIG. 2, *O*, *a–c*). The young zygosporangium thereupon developed as a subspherical enlargement, most often midway between base and apex of the distal gametangium, and less frequently in close proximity to the conjugation-tube, whether at the base of the distal gametangium (FIG. 2, *C*, *b*) or at the distal end of the proximal gametangium (FIG. 2, *P*). Relatively wide spatial separation of conjugation-tube and zygosporangium resulted occasionally from development of the latter toward the tip of the distal gametangium (FIG. 2, *N*, *Q*, *R*).

Once the globose zygosporangium had attained definitive size it was delimited proximally and distally by septa laid down in approximately tangential planes. Its originally smooth enveloping membrane would ultimately collapse somewhat loosely about the bullate contours of the yellowish zygospore. At maturity the zygospore, like that of other Zoöpagaceae, revealed an internal organization more familiar in oöspores: the thick spore wall surrounding a parietal layer of granular protoplasm, within which a largish reserve globule and a smaller oblate ellipsoidal refringent body were to be distinguished (FIG. 2, *S*, *a–q*).

Although formation of sexual spores on slightly thickened branches is known also in *Zoöpage cladosperma* Drechsl. (3), lateral conjugation has not hitherto been observed in any other member of the Zoöpagaceae. Frequently, indeed, union of the adjacent gametangia is accomplished by the fungus after a manner hardly

familiar in any groups of cryptogams. For while the conjugation tube here is sometimes present as a commonplace short direct connection comparable to the lateral connections in species of *Spirogyra,* it more often takes a curiously circuitous course (FIG. 2, *O, c; Q; R*), winding about the parent branch in a complete turn, to give somewhat the appearance of a circular flange or collar. In most instances of such circumvolution the intricated parts are too badly obscured to permit their relationship to be made out with any clearness. This circumstance, together with the small dimensions of the apparatus generally, has made it difficult to determine whether the conjugation-tube may not in some cases originate from the proximal rather than from the distal gametangium, or, again, whether the tube may not result from apical fusion of two processes put forth separately by the two gametangia.

A term suggested in part by the frequent similarity of the conjugation-tube to a circular fastening, and in part by the development of this unusual structure on branches, may serve appropriately as specific name for the fungus.

Acaulopage gomphoclada sp. nov.

Mycelium sparsum, parce ramosum; hyphis continuis, hyalinis, leniter flexuosis, .6–1.3 μ crassis, ad animalcula inhaerentibus, pelliculam cujusque capti perforantibus, haustorium intrudentibus quod protoplasma exhaurit; haustoriis pediculatis, pediculo saepius 1.5–3 μ longo, .6–1 μ crasso, abrupte latescente, apice semel vel ter repetite bifurco, ita 2–8 ramulos assumentes divaricatos 1.5–8 μ longos 1.2–1.8 μ crassos ferente. Conidia hyalina, erecta, ex sterigmatis 1 μ altis oriunda, ex partibus duabus composita: parte supera vacua, 8–20 μ longa, circiter .5 μ crassa, vulgo plus minusve marcida vel collapsa; parte infera protoplasmatis repleta, cylindrata vel elongato-fusiformi, 11–22 μ longa, 1.3–1.8 μ crassa. Ramuli zygosporiferi vulgo 15–50 longi, 1.2–2 μ lati, quoque binas cellulas sexuales (gametangia) ferente, una terminali et saepius 12–20 μ longa, altera huic proxime posita et saepius 2–10 μ longa; tubulo conjugationis a latere excrescente, interdum circum ramulum voluto; zygosporangio plerumque ex cellula sexuali terminali orto, primum levi, sphaeroideo, 7–10 μ crasso, membrana hujus mox circum zygosporam laxe collapsa; zygospora flavida, globosa, verrucosa, saepius 6–9 μ crassa, maturitate membrana ejus .6–1.8 μ crassa, corpus protoplasmatis sphaerale 4.5–6 μ crassum circumdante.

Amoebas 10–40 μ latas capiens consumensque habitat in foliis putrescentibus *Poae pratensis* prope Beltsville, Maryland.

Mycelium sparse, sparingly branched; the vegetative hyphae continuous, hyaline, slightly flexuous, .6 to 1.3 μ wide, capturing minute

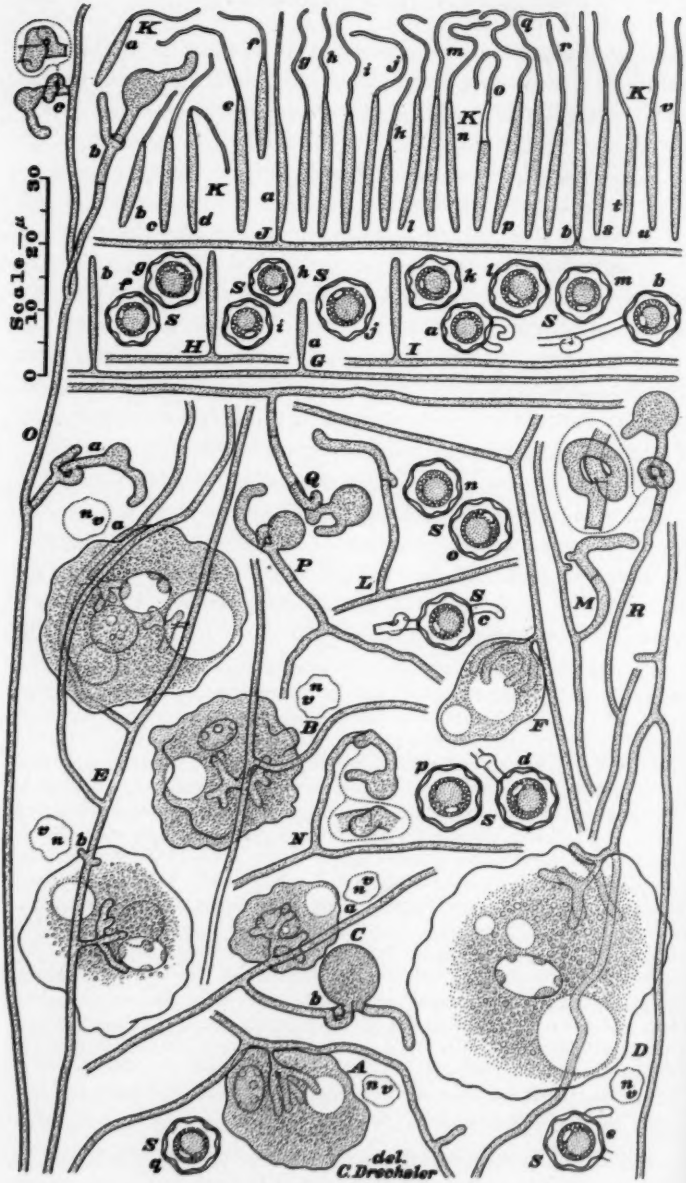

FIG. 2. *Acaulopage gomphoclada.*

animals through adhesion, then penetrating the pellicle of each captive and intruding into it a haustorium to appropriate the protoplasmic contents; haustoria pedicellate, the pedicel usually 1.5 to 3 μ wide and .6 to 1 μ thick, widening abruptly and bifurcating 1 to 3 times to terminate in 2 to 8 divergent assimilative branches 1.5 to 8 μ long and 1.2 to 1.8 μ wide. Conidia hyaline, erect, arising singly from sterigmata 1 μ long, each spore consisting of 2 parts: a distal empty part, mostly 8 to 20 μ long and about .5 μ wide, often present as a withered appendage; and a proximal part filled with protoplasm, cylindrical with somewhat tapering ends or elongate fusiform, measuring 11 to 22 μ in length and 1.3 to 1.8 μ in width. Paired sexual cells (gametangia) formed adjacent to each other by deposition of 2 septa in slightly widened lateral branches which often measure 15 to 50 μ in length and 1.2 to 2 μ in thickness—one of the cells, usually 12 to 20 μ long, constituting the terminal segment of the branch; the other, in penultimate position, varying usually from 2 to 10 μ in length. Conjugation always of lateral type, the tube sometimes short and direct, but more often somewhat circuitous in course and often rather closely enwrapping the lower portion of the distal cell and the upper portion of the proximal cell; zygosporangium most frequently formed about midway between base and tip of the distal cell, subspherical, commonly 7 to 10 μ in diameter, at first smooth, its envelope later collapsing somewhat loosely about the zygospore; zygospore yellowish, subspherical, commonly 6 to 9 μ in diameter, rather prominently verrucose, its wall .6 to 1.8 μ in thickness, surrounding a spherical protoplast usually 4.5 to 6 μ in diameter.

Capturing and consuming amoebae 10 to 40 μ wide it occurs in decaying leaves of *Poa pratensis* near Beltsville, Md.

A ROBUST COCHLONEMA WITH SMALL VERRUCOSE CONIDIA

Several maizemeal-agar plate cultures which after being permeated with mycelium of *Pythium myriotylum* Drechsl. had received some addition of partly decayed bluegrass leaves removed on May 10, 1941, from a heap of old lawn clippings in Arlington, Va., showed 11 days later many scattered white tufts just visible to the naked eye under strong lateral illumination. Examined microscopically under low magnification the tufts were found to consist of conidial chains and of moniliform filaments destined for conversion into conidial chains. The chains and filaments varied in number mostly from 10 to 25, and arose, erect or ascending, in bush-like arrangement, from a common origin. In general ap-

pearance the tufts resembled more particularly the conidiiferous tufts of *Cochlonema symplocum* Drechsl. (**6**), and the constituent spores, as in that species, were markedly verrucose. Despite these similarities it was evident, even with low magnification, that the catenated spores here were shorter than the homologous bodies of either *C. symplocum* or *C. verrucosum* Drechsl. (**1**).

Consonant with expectations suggested by the resemblances, the tufts on being examined under high magnification were found to originate from spiral thalli lying within collapsed pellicles of amoebae whose protoplasm had either wholly or in large part disappeared. Many animals (FIG. 3, *A–F*) showing earlier stages of infection moved slowly about on the substratum, the smaller individuals measuring approximately 35 μ across when drawn into a somewhat rounded form (FIG. 3, *A*), the larger ones of similar conformation (FIG. 3, *F*) attaining widths sometimes in excess of 60 μ. Each infected specimen was enveloped in a very thin pellicle, delicately rippled all around except where a broad pseudopodium was actively being pushed forward. During the earlier stages of parasitic attack, before pathological changes became noticeable, the host protoplasm remained of a finely granular consistency, permitting easy recognition of the single nucleus (FIG. 3, *A, n–F, n*) and of the contractile vacuole (FIG. 3, *A, v–F, v*). Prolate ellipsoidal in shape and measuring 10 to 14.5 μ and 8 to 11 μ along its major and its minor axis respectively, the nucleus was distinguished especially by circulatory movement, close under its peripheral membrane, of about 30 to 35 slightly darker subspherical or oblate ellipsoidal bodies ranging between 1 μ and 2 μ in greatest dimension. The number of intranuclear bodies, as also their curious cyclosis, appeared to indicate close kinship of the host rhizopod with the *Amoeba* previously observed being utilized as prey by *Stylopage cephalote* (**4**). While the animals attacked by the catenulate fungus were generally larger than those earlier found being captured by the capitate form, the difference in size was hardly sufficient to exclude the likelihood that the same protozoan species might have been concerned in both instances.

Infection is initiated through germination of a conidium (FIG. 3, *A*) or of several conidia (FIG. 3, *B*) unhappily ingested by the animal. The germ-tube put forth laterally or somewhat obliquely

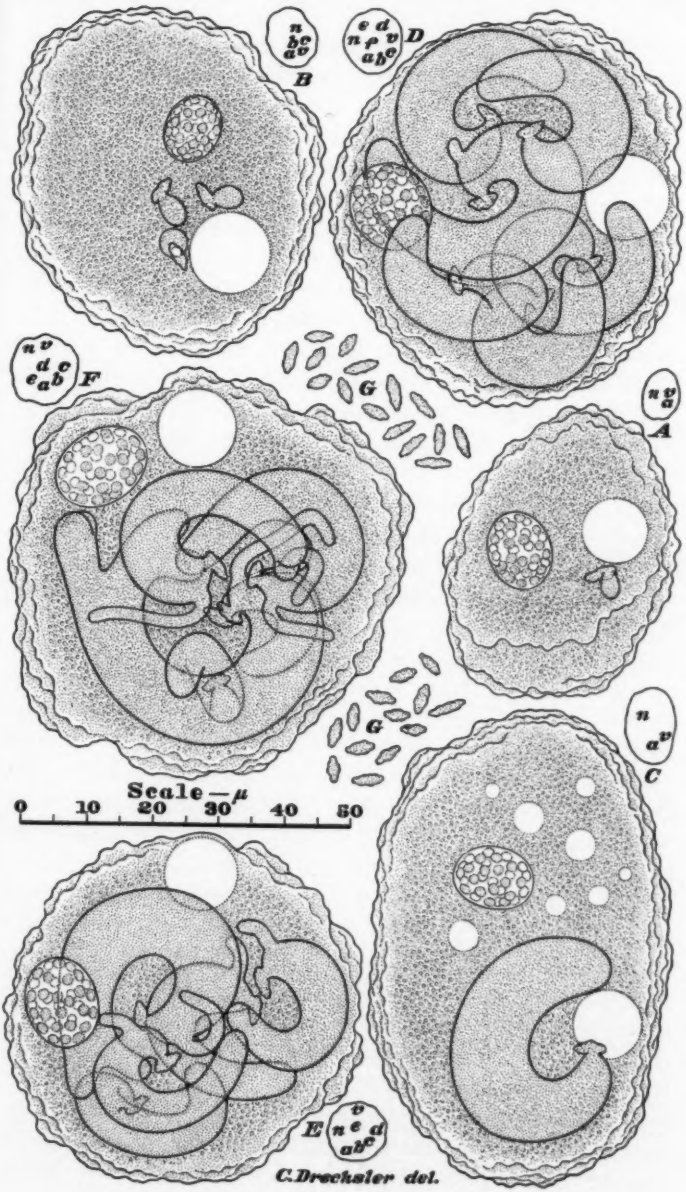

FIG. 3. *Cochlonema curyblastum.*

from the spore is much stouter than the proximal portions of corresponding outgrowths in *Cochlonema symplocum* and *C. verrucosum*. During early stages of growth it widens rather markedly, though soon further elongation proceeds at a nearly uniform or gradually diminishing diameter (FIG. 3, *C, a; D, a–e; E, a, b*). As the young thallus lengthens it curves into a flat spiral. Branching for the most part takes place only after a complete turn has been described, and consequently often remains absent in thalli that have failed to attain the necessary proportions before their food supply has been exhausted. Whether a thallus concludes its development as a simple hypha, or as a branched hypha, depends, therefore, not only on the size of the animal host, but also on the measure in which other thalli participate in the expropriation of available protoplasmic materials. In instances where a host animal, even of relatively large size, is infected simultaneously by 5 or 6 conidia, so that its substance is rather equally divided between a corresponding number of thalli, all of the thalli may remain simple (FIG. 3, *D, a–f*), though in instances of multiple infection at separate times, where, for example, 1 or 2 of the thalli have begun development earlier than their fellows, the older individuals may become branched (FIG. 3, *E, e; F, d, e*). When an animal has been infected simultaneously by only 3 conidia, all of the resulting thalli may show branching (FIG. 4, *A*), though naturally more abundant ramification is afforded when only a single thallus is present (FIG. 4, *B–D*), and especially when a single thallus has developed in an animal of unusually large size (FIG. 4, *C, D*). The first bifurcation, as in *C. megalasomum* Drechsl. (**5**), usually takes place in the plane of the first spiral coil (FIG. 3, *E, d; F, e.* FIG. 4, *A, a, b; B; C; D*), though occasionally a primary dichotomy may be somewhat oblique to that plane (FIG. 4, *A, c*). Some dichotomies of the second order (FIG. 3, *F, e*) as well as some of the third (FIG. 4, *D*) and fourth (FIG. 4, *C*) orders, when such higher ramifications are present, also lie in the plane of the first spiral coil. The generally flat spiral conformation maintained up to the second dichotomies is rather little disturbed by irregularity of angular relationships in the second, third, and fourth bifurcations, since the branches resulting from these later ramifications are so markedly reduced in length and thickness that they constitute only a small portion of the whole thallus.

When the animal host has been disabled for further locomotion, owing to continuing loss of protoplasm, the thallus initiates asexual reproduction by putting forth a reproductive hypha from a position on its convex profile usually 3 to 10 μ from its origin (FIG. 3, *D, f; E, b–e; F, c, d.* FIG. 4, *A, a–c; B*). If the thallus is large a second reproductive hypha is put forth simultaneously from a position on the convex profile usually 3 to 10 μ beyond the first (FIG. 3, *F, e.* FIG. 4, *C, D*). After growing through the enveloping host pellicle each reproductive hypha branches several times (FIG. 4, *B*) to extend into the air eventually from 3 to 15 filaments beset with warty protuberances and noticeably constricted at close intervals. Once the individual filament has reached definitive length, it is converted into a chain of verrucose conidia through deposition of cross-walls at the constrictions (FIG. 3, *G.* FIG. 4, *C, E*). Development of the several spore chains that originate from the same reproductive hypha is in considerable measure successive, additional sporiferous branches being extended until the thallus has yielded up all its contents. Departure of protoplasm from a thallus is accompanied by progressive, conspicuous vacuolization (FIG. 4, *C; D; E*), but apparently does not entail deposition of retaining septa within the thallodic envelope.

The parasite is obviously referable to *Cochlonema,* and in that genus appears most closely akin to *C. verrucosum* and *C. symplocum.* From these species it differs markedly with respect to vegetative habit, especially when its thallus attains a size large enough to permit repeated branching. Since, however, the distinctly broad attachment between germinating conidium and thallus is observable much more often than abundant distal ramification, the fungus is described under an epithet compounded of two words meaning "wide" and "sprout," respectively.

Cochlonema euryblastum sp. nov.

Hyphae assumentes protinus ex tubo germinationis saepius 1.5–2 μ crasso latescentes, hyalinae, continuae, 6–15 μ crassae, usque 125 μ longae, in spiram planam semel subinde paene bis volutae, nunc simplices nunc semel bifurcae nunc etiam bis vel ter vel quater crebro dichotomae, prope originem ex latere convexo unam hypham genitabilem vel quandoque duas hyphas genitabiles emittentes; hyphis genitabilibus 2–3.2 μ crassis, quoque sursum 3–15 ramos erectos vel ascendentes in aerem proferente qui in catenulas 30–80 conidiorum abeunt; conidiis hyalinis, verrucosis, plerumque 3–6 μ longis, 1.5–2 μ crassis.

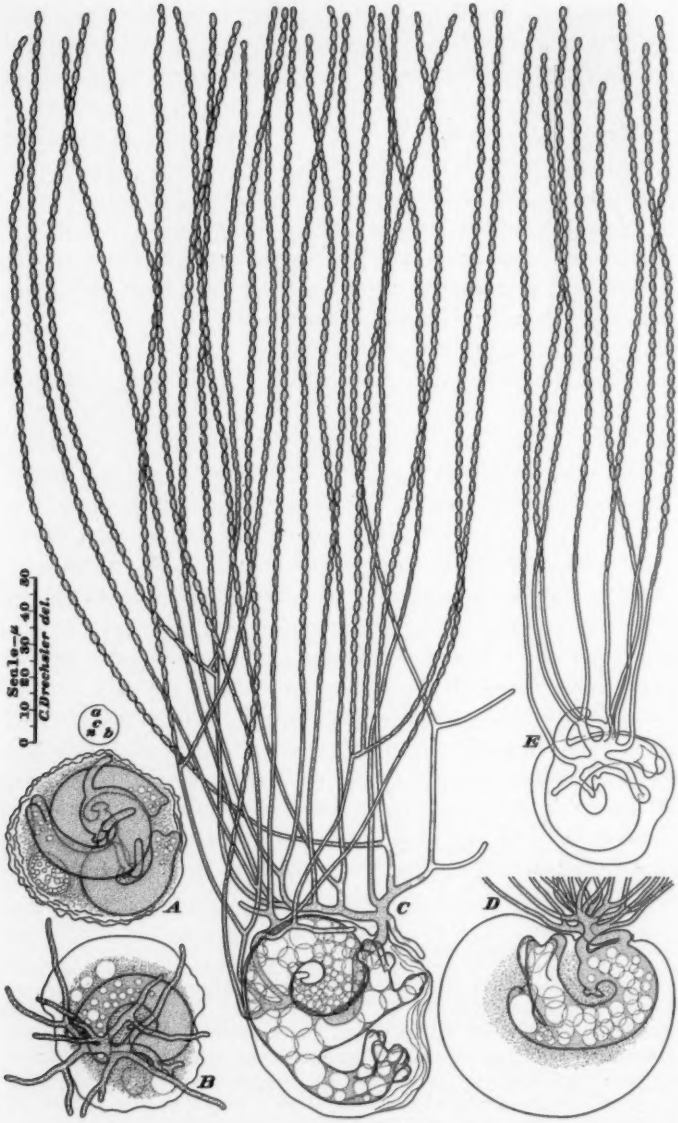

FIG. 4. *Cochlonema euryblastum.*

Amoebas vulgo 35–60 μ latas enecans habitat in foliis *Poae pratensis* putrescentibus in Arlington, Virginia.

Assimilative hyphae widening out immediately from a germ-tube often 1.5 to 2 μ in thickness, hyaline, continuous, 6 to 15 μ in diameter, up to 125 μ in length, convolved in a flat spiral of one turn or occasionally of nearly two turns, often simple but sometimes once bifurcate and occasionally even further dichotomizing, though at shorter intervals, a second, third, or fourth time; the smaller specimens putting forth, from a position on the convex profile close to the proximal end, a single reproductive filament, the larger specimens putting forth 2 such filaments. Reproductive filaments 2 to 3.2 μ wide, each extending into the air 3 to 15 branches, which soon are converted in large part into chains of 30 to 80 conidia; conidia hyaline, warty, mostly 3 to 6 μ long and 1.5 to 2 μ wide.

Destroying amoebae commonly 35 to 60 μ wide it occurs in decaying leaves of *Poa pratensis* in Arlington, Va.

UTILIZATION BY ACAULOPAGE TETRACEROS OF THE AMOEBA CAPTURED BY ZOÖPAGE THAMNOSPIRA

In the original description of *Acaulopage tetraceros* little information was supplied relative to the morphology and specific identity of the animals found captured by the fungus. Cultures abundantly bestrewn with inversely lageniform and plurally appendaged conidia have come under observation from time to time in subsequent years, without, however, providing much additional knowledge of the prey; for usually when asexual reproduction had advanced far enough to invite attention, predaceous activity had virtually come to an end. Better success attended observations on an old *Pythium* culture to which had been added a few pinches of leaf mold collected in deciduous woods near Beltsville, Md., on January 7, 1941. Ten days after the decaying refuse was added predaceous activity appeared in two separate areas, and accompanying it, early development of conidia in sufficient quantity to permit identification of the two distinct zoöpagaceous forms concerned. In one of the tracts *Zoöpage thamnospira* Drechsl. (**4**) was readily recognized both from the morphology of its catenulate conidia, and from the gracefully coiled, thallus-like haustoria it extended into the captured amoebae. As in the cultures whereon the description of *Z. thamnospira* was based, the prey often measured about 40 μ across when

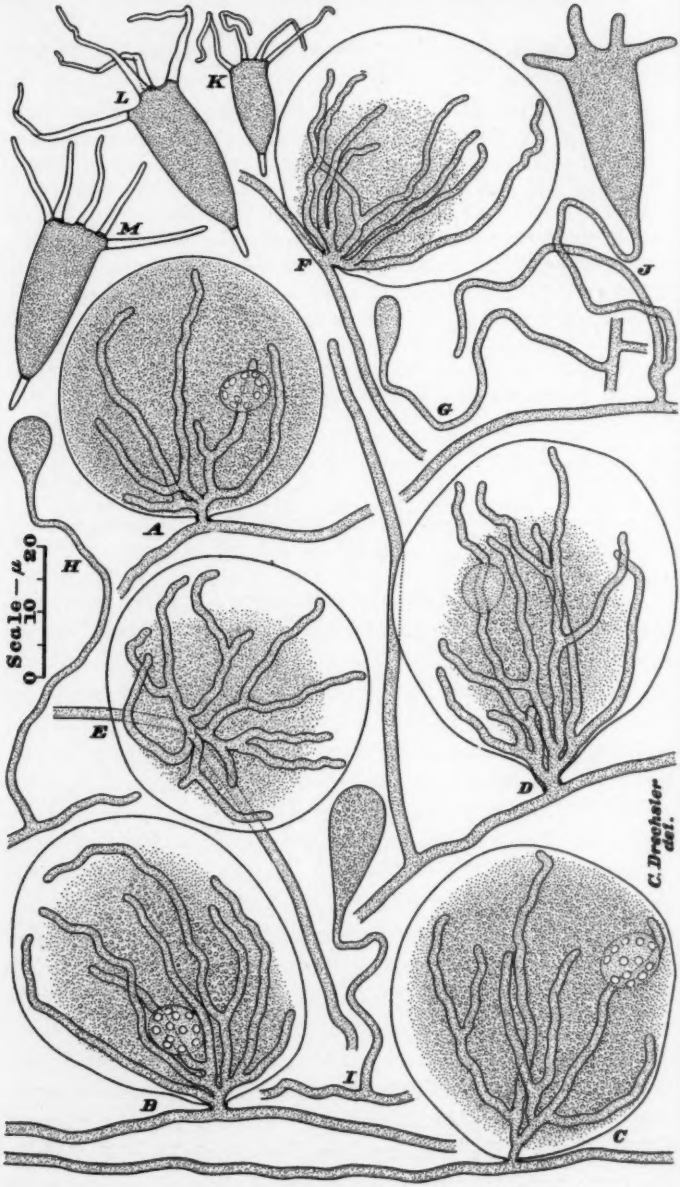

FIG. 5. *Acaulopage tetraceros.*

drawn into an approximately round shape, and contained a prolate ellipsoidal nucleus within which a dozen somewhat flattened orbicular bodies were distributed in positions close under the peripheral membrane. Amoebae entirely similar with respect to dimensions and nuclear organization (FIG. 5, *A–C*) were preyed upon also in the other tract of substratum, where, however, the protoplasmic materials were assimilated by means of more commonplace bush-like haustoria whose rangy branches showed no coiling and did not exceed the parent filaments in width (FIG. 5, *D–F*). Here and there the mycelial hyphae bore prostrate branches on whose erect tips were borne swollen bodies in various stages of development (FIG. 5, *G–J*) into conidia typical of *A. tetraceros* (FIG. 5, *K–M*). Accordingly the species of *Amoeba* habitually captured by *Z. thamnospira* is to be recognized also as prey of *A. tetraceros*. The animal further seems to be an intimate relative of the *Amoeba* parasitized by *Cochlonema euryblastum*, since its prolate elliptical nucleus, like that of the latter protozoan, shows orbicular bodies in gentle rotational movement close under the peripheral membrane. Yet as the rotating intranuclear bodies present here are conspicuously less numerous than those present in the host of *C. euryblastum*, the rhizopods are perhaps better considered to be merely congeneric rather than conspecific.

A VARIETY OF COCHLONEMA BACTROSPORUM WITH LONG CONIDIA

Seven weeks after some pinches of leaf mold collected near Haugen, Wis., in September 1939, had been added to an old *Pythium* culture on maizemeal agar, the medium adjacent to one of the deposits showed a colony of *Heleopera sylvatica* Penard (**7**), numbering nearly a hundred individuals, being exterminated by a *Cochlonema* corresponding in nearly all respects to the description of *Cochlonema bactrosporum* (**5**). On close scrutiny it was found that the animals undergoing destruction were noticeably larger than those previously found parasitized in the cultures planted with decaying material from Beltsville, Md.; for they measured about 80 μ in average length, and about 50 μ in average width, as compared with corresponding values of 65 μ and 42 μ, respectively, derived from measurements of the earlier specimens. As far as

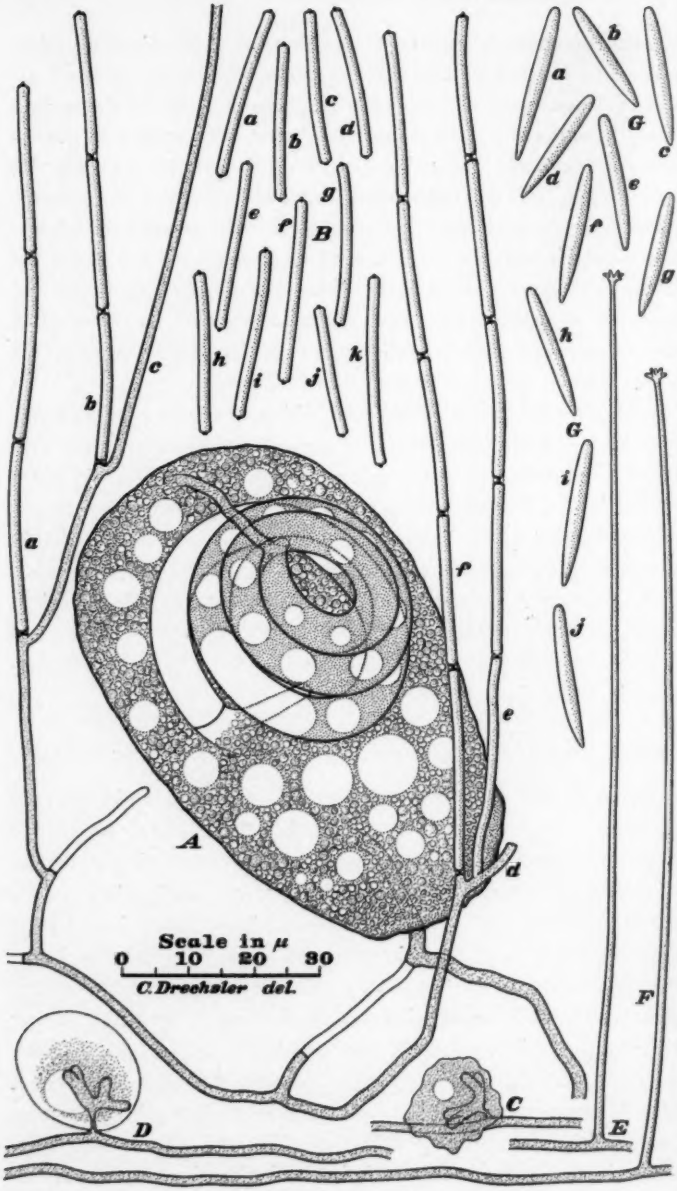

FIG. 6. *A, B, Cochlonema bactrosporum* var. *longius; C–G, Stylopage cephalote.*

could be determined under very troublesome optical difficulties arising from the globulose texture of the degenerating host protoplasm, the grandiose helicoid thalli of the parasite (FIG. 6, *A*) resembled those previously encountered; and the resemblance extended evidently both to the reproductive filaments and to the aerial sporiferous branches while in immature condition. However segmentation of the aerial branches (FIG. 6, *A, a–f*) here resulted in conidia (FIG. 6, *B, a–k*) fully half again as long as those of the Maryland fungus. Since the material from either of the two sources showed only moderate variability in conidial length, the fungus from Wisconsin would seem to merit recognition as a distinct variety.

Cochlonema bactrosporum var. **longius** var. nov.

Speciei typicae simile ad hypham alitam et hyphas fertiles; conidiis catenulatis, hyalinis, levibus, cylindratis, vulgo 20–31 μ longis, 1.6–1.9 μ crassis, utrimque in verruculam minutam abeuntibus.

Heleoperam sylvaticam formae grandis enecans habitat in humo silvestri prope Haugen, Wisconsin.

Similar to the type of the species with respect to vegetative hypha and conidiiferous filaments; conidia catenulate, hyaline, smooth, cylindrical, commonly 20 to 31 μ long, 1.6 to 1.9 μ wide, at each end terminating in a minute warty protuberance.

Destroying *Heleopera sylvatica* of a large type, it occurs in leaf mold near Haugen, Wis.

SUPPLEMENTARY OBSERVATIONS ON STYLOPAGE CEPHALOTE

The same set of cultures that after being planted with partly decayed blue-grass leaves gave rise to *Cochlonema euryblastum* afforded development also of *Stylopage cephalote*. The latter fungus here subsisted through capture of an *Amoeba*, within whose prolate ellipsoidal nucleus about a dozen orbicular bodies appeared in gentle movement close under the peripheral membrane. With respect to number of intranuclear bodies, therefore, the animal agreed rather accurately with the *Amoeba* found subject to capture by both *Acaulopage tetraceros* and *Zoöpage thamnospira*.

Stylopage cephalote also developed rather abundantly in several maizemeal-agar plate cultures that had been planted with a few pinches of leaf mold from a collection of this material made near Charleston, S. C., in February, 1941. At the time observations

were begun the fungus had nearly concluded its vegetative growth. Only a few small amoebae were found adhering to the hyphae in newly captured condition (FIG. 6, *D, C*); the captives measuring about 15 μ across when drawn into an approximately round shape, and revealing no nucleus in their turbid protoplasm. Remnants of pellicles more capacious than any that could have been left by such small animals were found attached here and there, indicating that larger prey may previously have been exterminated in furnishing a richer supply of nourishment. Many of the conidiophores arising from the predaceous filaments showed dimensions in tolerable agreement with the original description of the species (**4**); though others, again, gave measurements for height in excess of 120 μ or 130 μ (FIG. 6, *E, F*), and measurements for subterminal width as small as .6 μ or .8 μ. The conidia (FIG. 6, *G, a–j*) produced on these taller and more slender supporting hyphae showed no concomitant departure in morphology.

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LITERATURE CITED

1. **Drechsler, C.** Some conidial Phycomycetes destructive to terricolous Amoebae. Mycologia **27**: 6–40. 1935.
2. ——. Some non-catenulate conidial Phycomycetes preying on terricolous Amoebae. Mycologia **27**: 176–205. 1935.
3. ——. New conidial Phycomycetes destructive to terricolous Amoebae. Mycologia **28**: 363–389. 1936.
4. ——. New Zoöpagaceae capturing and consuming soil Amoebae. Mycologia **30**: 137–157. 1938.
5. ——. A few new Zoöpagaceae destructive to large soil rhizopods. Mycologia **31**: 128–153. 1939.
6. ——. Four Phycomycetes destructive to nematodes and rhizopods. Mycologia **33**: 248–269. 1941.
7. **Penard, E.** Faune rhizopodique du bassin du Léman. 1902.

EXPLANATION OF FIGURES

FIG. 1. *Acaulopage lasiospora;* drawn with the aid of a camera lucida to a uniform magnification; × 1000 throughout. *A,* Portion of hypha on which a relatively large amoeba has been captured by adhesion; at each of the three places of adhesion a haustorium is shown growing into the protoplasm; within the animal's body are visible also ten small contractile vacuoles

and three round bodies of uncertain function. *B*, Portion of mycelium with a captured amoeba; the latter being shown at an early stage of invasion by the haustorium. *C*, Portion of hypha on which two amoebae, *a* and *b*, have been captured by adhesion; within the sarcode of each animal portions of haustorial branches are faintly visible here and there. *D*, Portion of hypha with a captured amoeba within whose dense protoplasm portions of haustorial branches are faintly visible. *E*, Portion of hypha on which two small amoebae, *a* and *b*, have been captured; the smaller captive, *a*, has been depleted of protoplasm in sufficient measure to make the haustorium faintly visible throughout; in the slightly larger captive, *b*, depletion of protoplasm is further advanced, so that the haustorium has become clearly visible throughout. *F*, Portion of mycelium with two captured amoebae, *a* and *b*; each captive having been expropriated of its contents in such large measure that the haustorium has become clearly visible. *G*, *H*, *I*, Portions of mycelium, each with a captured amoeba; each captive has been almost wholly depleted of its protoplasm, so that the haustorium is clearly visible. *J–P*, Fertile branches, each bearing a growing conidium at its tip. *Q*, Portion of mycelium with a young conidium from which protuberances are being extended. *R*, Portion of mycelium with two conidia, *a* and *b*, whose protuberances are fully extended. *S*, Portion of hypha with a conidium whose fully extended and evacuated protuberances are arranged asymmetrically relative to the conidial axis. *T*, Mature conidium shown attached to a supporting branch from which the protoplasmic contents have been mostly withdrawn. *U*, Mature or nearly mature conidium attached to a branch that is still filled with protoplasm. *V*, Mature conidia, *a–g*, showing variations in size and shape of living cell, as well as in number, dimensions, and distribution of the empty appendages.

FIG. 2. *Acaulopage gomphoclada;* drawn with the aid of a camera lucida to a uniform magnification; × 1000, except for supplementary drawings (each surrounded by a dotted line) showing details of conjugation in *N*, *O*, *R*, which are reproduced at a magnification of about 2000 diameters. *A*, *B*, Portions of mycelium, each with a captured amoeba into which a haustorium has been intruded; *n*, nucleus of animal; *v*, contractile vacuole. *C*, Portion of hypha which besides intruding a haustorium into the captured amoeba *a*, has given rise to a sexual branch, *b*, showing development of a nearly full-grown zygosporangium; *n*, nucleus of captured amoeba; *v*, contractile vacuole. *D*, Portion of mycelium with a captured amoeba whose contents have been largely assimilated by means of a single haustorium; *n*, nucleus of amoeba; *v*, contractile vacuole. *E*, Portion of mycelium from which two haustoria have been intruded into a captured amoeba, *a*, while a single haustorium has been intruded into a second amoeba, *b*; *n*, nucleus of each amoeba; *v*, contractile vacuole of each amoeba. *F*, Portion of mycelium from which a haustorium has been intruded into a captured amoeba. *G*, Terminal portion of a mycelial filament, showing two conidia, *a* and *b*, in early stages of development. *H*, *I*, Portions of mycelial hypha, each showing an early stage in development of a conidium. *J*, Portion of mycelium showing one conidium, *a*, in an advanced stage of development, and another, *b*, in mature condition. *K*, Mature conidia, *a–v*, showing variations in the dimensions both of the living cell and of the empty appendage. *L*, *M*, Portions of mycelial hyphae,

each bearing a sexual reproductive branch in an early stage of development. *N*, Portion of hypha bearing a sexual branch with a conjugation-tube and a young zygosporangium. *O*, Portion of hypha bearing three sexual branches, *a*, *b*, *c*, each showing a conjugation-tube and a young zygosporangium. *P*, *Q*, *R*, Portions of mycelial hyphae, each bearing a sexual branch with a half-grown zygosporangium. *S*, Mature zygospores—some of them, *a–e*, shown with empty attachments; the others, *f–q*, shown without empty parts.

FIG. 3. *Cochlonema euryblastum;* drawn to a uniform magnification with the aid of a camera lucida; × 1000 throughout. *A*, Small specimen of the susceptible *Amoeba*, within which a single conidium, *a*, has begun to germinate; *n*, nucleus of host animal; *v*, contractile vacuole. *B*, Medium-sized specimen of the susceptible *Amoeba*, within which three conidia, *a*, *b*, *c*, have begun to germinate; *n*, nucleus of host animal; *v*, contractile vacuole. *C*, Rather large specimen of host *Amoeba* containing a single growing thallus, *a;* *n*, nucleus of host animal; *v*, contractile vacuole. *D*, Large specimen of host *Amoeba* containing six thalli, *a–f*, one of which, *f*, has begun putting forth a reproductive hypha; *n*, host nucleus; *v*, contractile vacuole. *E*, Fairly large specimen of host *Amoeba* containing five thalli, *a–e*, of which four, *b–e*, have each begun to put forth a reproductive hypha; *n*, host nucleus; *v*, contractile vacuole. *F*, Large specimen of host *Amoeba* containing five thalli, *a–e*, two of which, *c*, *d*, are each putting forth a single reproductive hypha, while another, *e*, of greater size, is putting forth two reproductive hyphae; *n*, host nucleus; *v*, contractile vacuole. *G*, Random assortment of conidia, showing variations in size, shape and sculpturing.

FIG. 4. *Cochlonema euryblastum;* drawn to a uniform magnification with the aid of a camera lucida; × 500 throughout. *A*, Specimen of host *Amoeba*, within which three thalli, *a*, *b*, *c*, have developed; each thallus shows a single dichotomy, and each has begun to put forth a single reproductive hypha; *n*, host nucleus. *B*, Specimen of host *Amoeba* whose protoplasmic contents have been assimilated almost entirely in the development of the distally bifurcate thallus, which near its proximal end has put forth a reproductive hypha that has produced several branches destined to grow into sporiferous aerial filaments. *C*, Collapsed pellicle of a parasitized *Amoeba*, within which a large thallus with four successive bifurcations has developed; the thallus, though not yet wholly depleted of contents, has put forth two reproductive hyphae, which together have given rise to three conidiiferous hyphae and twenty chains of conidia. *D*, Specimen of host *Amoeba* containing a thallus with three successive bifurcations; at its proximal end the thallus has put forth two reproductive hyphae that have branched copiously in giving rise to aerial conidiiferous hyphae whereof only the basal portions are shown. *E*, Empty pellicle surrounding membranous envelope of twice bifurcate thallus, which at its proximal end has put forth a single reproductive filament that has branched in giving rise to eight chains of conidia.

FIG. 5. *Acaulopage tetraceros;* drawn with the aid of a camera lucida to a uniform magnification; × 1000 throughout. *A*, *B*, *C*, Portions of hyphae with captured specimens of *Amoeba* sp., into which rangy arbuscular systems have been extended; each captive reveals a nucleus of approximately normal structure. *D*, *E*, *F*, Portions of hyphae with captured specimens of *Amoeba* sp.; the captives have lost nearly all their protoplasmic contents, and their

nuclei are no longer clearly recognizable. *G, H, I, J,* Creeping mycelial branches on each of which a conidium is being formed terminally. *K, L, M,* Mature conidia.

FIG. 6. Drawn with the aid of a camera lucida to a uniform magnification; × 1000 throughout.

A, B, Cochlonema bactrosporum var. *longius: A,* Specimen of *Heleopera sylvatica* containing a helicoid thallus of the parasite; from its proximal end the thallus has put forth a reproductive hypha, which on emerging from the mouth of the animal host has sent a few short branches into the substratum and given rise to two main branches; from one of these main branches two conidial chains *a, b,* and a young sporiferous hypha, *c,* have been extended, while the other main branch has given rise to three chains of conidia, of which two, *e* and *f,* are still intact, whereas the third is represented only by a sterile basal support *d.* (Owing to lack of space only proximal portions of the sporiferous hypha and of the four conidial chains are shown.) *B,* Random assortment of conidia, *a–h,* showing variations in length.

C–G, Stylopage cephalote from a culture planted with leaf mold collected in South Carolina: *C,* Portion of hypha from which a pedicellate haustorium has been intruded into a small amoeba captured through adhesion; though the captive is still alive, as is evident from the normal functioning of its contractile vacuole, no nucleus is visible in the turbid protoplasm. *D,* Portion of hypha from which a haustorium has been intruded into a captured amoeba; as the protoplasm of the captive has been very largely assimilated, the delicate pellicle has become flattened out so as to show a smooth outer contour. *E, F,* Portions of prostrate hyphae from which unusually tall slender conidiophores have arisen. *G,* Random assortment of conidia, *a–j,* showing usual variations in size and shape.

PHOTOGRAPHS AND DESCRIPTIONS OF CUP-FUNGI—XXXVI. A NEW SPECIES AND GENUS

FRED J. SEAVER

(WITH 1 FIGURE)

In 1934 (Mycologia **26**: 291.) Dr. S. M. Zeller described as new a fungus on the leaves of *Gaultheria Shallon* Pursh, and recorded it under the name *Dermatea brunneo-pruinosa*. The writer has never been able to determine why it should have been placed in that genus since it has none of the characters of *Dermatea*, as ordinarily understood. Zeller called attention to the fact that this fungus occurred on spots associated with *Pestalotia gibbosa* Hark., and that the two might be organically connected.

Recently (Mycologia **34**: 180.) Dr. Lee Bonar of California has established the connection suggested by Zeller, proving by culture that the ascospores of Zeller's proposed species on germination produce the conidial or *Pestalotia* stage.

This is especially interesting to the writer since in 1928 a large collection of leaves of *Rhododendron maximum* L. was received from Dr. F. A. Wolf of North Carolina showing diseased spots bearing a *Pestalotia* stage and an apothecial stage so similar to that described by Zeller that they were at first thought to be identical. While the connection between the *Pestalotia* and the associated ascomycete on *Rhododendron* has not been proven, it is so similar to the one described by Zeller that we assume the connection to exist. Since the conidial stages of the two fungi appear to be distinct we for the present assume that the perfect stages are also distinct.

Much confusion has arisen through the fact that J. B. Ellis distributed this species in Fungi Columbiani *331* as *Dermatea lobata* Ellis, and this was later referred to *Lachnella rufo-olivacea* (Alb. & Schw.) Sacc. While there is an external resemblance, the species differs widely in habitat and in its much larger spores as well as in its conidial association and probable connections.

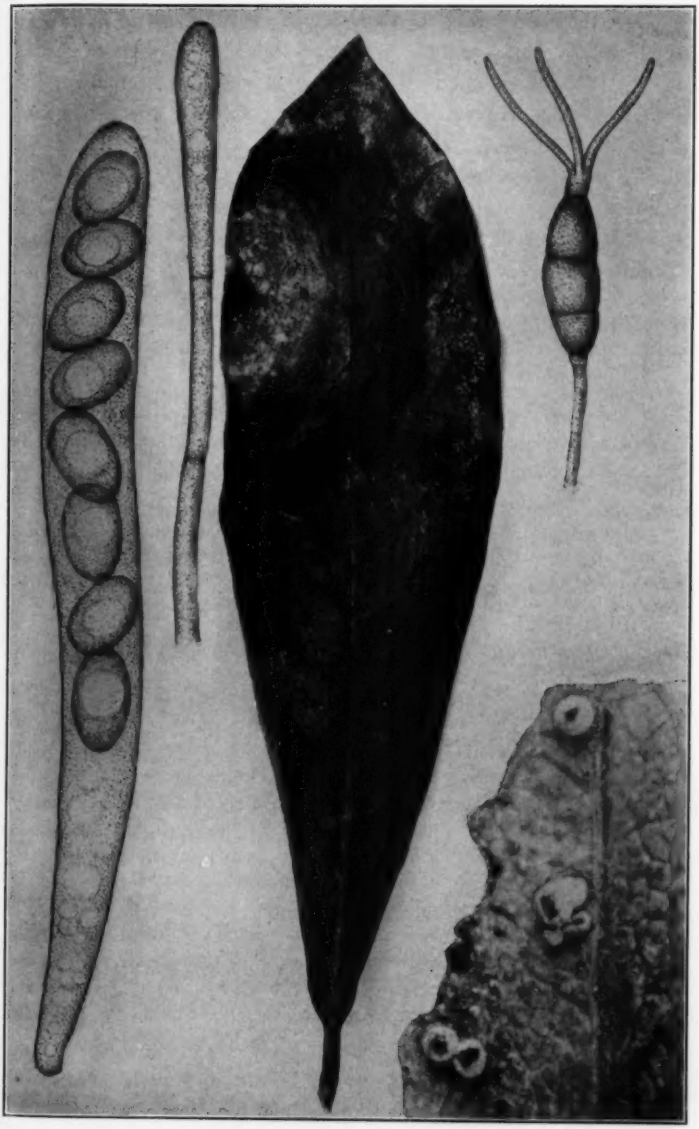

FIG. 1. *Pestalopezia Rhododendri.*

Since the species described by Zeller does not seem to fit well in the genus *Dermatea* and following the tendency to segregate genera on the basis of their conidial stages where these are known, the writer ventures to propose a new genus, combining the two names *Pestalotia* and *Peziza*. The form on *Rhododendron* is also recorded as a new species, but with the feeling that it may later be found to be identical with the form on *Gaultheria*. The following name is proposed for those species of cup-fungi which have a *Pestalotia* as their conidial stage.

Pestalopezia gen. nov.

Apothecia superficial, sessile or subsessile, at first subglobose becoming expanded and subdiscoid, externally pruinose or tomentose, light colored; hymenium becoming nearly plane, dark colored, almost black; asci 8-spored, subcylindric paraphyses filiform and rather strongly enlarged with a *Pestalotia* as its conidial stage.

Apotheciis superficialibus, sessilis vel subsessilis, primo subglobosis dein suborbicularis, extus pruinosis vel tomentosis; hymenio subatro; ascis subcylindraceis, 8-sporis; sporis ellipsoideis hyalinis; paraphysibus clavulatis, dilute fuligineis.

Type species: *Dermatea brunneo-pruinosa* Zeller, which would become **Pestalopezia brunneo-pruinosa** (Zeller) Seaver, comb. nov.

Pestalopezia Rhododendri sp. nov.

Apothecia sparingly scattered near the center of circular or subcircular dead spots apparently caused by the conidial or associated stage of the fungus *Pestalotia*, the spots becoming brown and bordered with concentric rings of variegated colors from red to brownish apothecia not exceeding 1 mm. in diameter, appearing as minute light colored balls, gradually expanding and exposing the dark colored discs; asci subcylindric to clavate, tapering into a short stem-like base, reaching a length of 150 μ and a diameter of 14 μ, 8-spored; spores 1-seriate, ellipsoid hyaline $8 \times 16\,\mu$; paraphyses slightly enlarged above pale brown, reaching a diameter of 6 μ at their apices.

Associated with what appears to be the *Pestalotia* stage, the spores with 3 brown cells $10 \times 20\,\mu$ exclusive of the basal cell and bearing three appendages at the opposite end.

Apotheciis sparsis in maculis orbicularibus dispositis cum *Pestalotia* sp., epiphyllis, vix 1 mm. diam. extus pallidis, pruinosis, sessilis; hymenio sordide nigro; ascis subcylindraceis vel clavatis; sporis 8, ellipsoideis, hyalinis, 8 × 16 μ; paraphysibus dilute brunneis, 6 μ diam.

Pestalotia sp. Sporis brunneis, biseptatis 10 × 20 μ ciliis in vertice tribus; pedicello hyalino.

On dead spots on leaves of *Rhododendron maximum* L., Pineola, North Carolina, July, 1938.

EXPLANATION OF FIGURE

Center, photograph of leaf of *Rhododendron maximum* L. infected with *Pestalotia* sp. and the apothecia of *Pestalopezia Rhododendri*. Lower right corner, photograph of several apothecia much enlarged. Left, an ascus and paraphysis much enlarged. Upper right corner, one spore of the *Pestalotia* associate.

CONJUGATE NUCLEAR DIVISION IN THE FUNGI

B. O. Dodge

(with 2 figures)

The term conjugate division has long been used to indicate that type of simultaneous division just preceding spore formation in sori of the rusts. Conjugate division also occurs in crosier formation in ascomycetes and in clamp connections of the hymenomycetes. The essential idea is that the spindles of the two nuclei lie more or less parallel and that septa cut across the spindles. One can not very well attribute a sex function to it in one instance and some other function when the occasion demands it. Whether or not the two nuclei so dividing are unlike genetically, or come from the same source or race has not been taken into consideration.

The mycelium of a homothallic mushroom is said to arise typically from a single spore with a single haploid nucleus. The germ tubes and even the earlier cells in the mycelium may be multinucleate. At a certain stage of maturity in some forms such as *Corticium coronilla*, a dicaryotic phase is established and clamps are regularly formed thereafter. Certainly in such forms the nuclei fusing in the basidium are alike genetically. No segregation occurs giving two kinds of spores so far as sex reactions are concerned. In such forms then the two nuclei dividing conjugately are the direct descendants through equational divisions from a single haploid nucleus.

We see so often in print statements that the binucleate or dicaryophytic stage of the rusts is maintained through conjugate nuclear division. The writer has never seen published any adequate evidence in support of such a statement. No doubt the nuclei of the "runner" cells do divide simultaneously, and no doubt the two nuclei of the pairs in the dicaryons in heterothallic species are direct descendants from two different sources or races. They are of opposite sex in their reactions. To say that the two nuclei in the rust

dicaryon divide conjugately and that septa are laid down across the spindles thus delimiting binucleate cells is going beyond what is so far known as a fact.

This whole question of the use of the term conjugate nuclear division is being tied up with the misuse of the term diploid. In certain basidiomycetes, such as *Coniophora cerebella,* there may be several clamp connections developed at each septum. A preparation sent to the writer by Dr. C. W. Emmons, shows plainly several pairs of "conjugate nuclei" in each cell. If a dicaryotic mycelium with one clamp at each septum is "diploid" a mycelium with two clamps at each septum, a tetracaryon, 4-nucleate cells, would be "tetraploid." The *Coniophora* mycelium would be "polyploid."

We are told that in those ascomycetes like *Neurospora* where the mycelial cells are multinucleate, the divisions are merely simultaneous and not conjugate at all. In those facultatively heterothallic species like *N. tetrasperma* and *Gelasinospora tetrasperma* the hyphal cells normally contain two kinds of nuclei as to their sex reactions. In these forms it is not unusual, just as has been reported for certain rusts, to find that nuclei of only one sex are cut off in certain branches. This is proof enough, one could say, that the two kinds of nuclei are not conjugate. This view then would provide a way of avoiding being compelled to call cells of *Neurospora* and *Gelasinospora,* "diploid" because they have two different kinds of nuclei, or worse still of calling them "polyploid" because each cell contains many sets of chromosomes. If conjugate division is the *sine qua non* for the new kind of "diploid," let us look at nuclear behavior in the ascus of *Gelasinospora tetrasperma.* Figure 1 adapted from illustrations published in Cytologia 1937, needs little comment. Suppose we try to apply the term "diploid" as it has been newly defined. The ascus, figure 1, *A,* with its fusion nucleus all agree is diploid. The first division occurs, leaving two haploid conjugate nuclei in the ascus. Since these nuclei differ genetically and are of opposite sex, and the cell contains two sets of chromosomes, the ascus is still "diploid" according to the new idea. Conjugate nuclear division occurs, ascus *B,* one pair of conjugate nuclei (two nuclei of opposite sex) moves to each end, ascus *C.* If one pair of conjugate nuclei makes a cell "diploid" two pairs make it "tetraploid." Perfect conjugate division occurs in both

pairs ending in a cell containing four pairs of conjugate nuclei. The ascus becomes "octoploid," ascus *E*. Here we have an exact replica of what occurs at the base of the aeciospore chain: conjugate division with a cutting across of the pairs of spindles by spore walls leaving a pair of conjugate nuclei in each spore, asci *F* and *G*. These spores are "diploid," but only for a few hours at most, because with another perfect conjugate division, *J*. *K*, each spore is

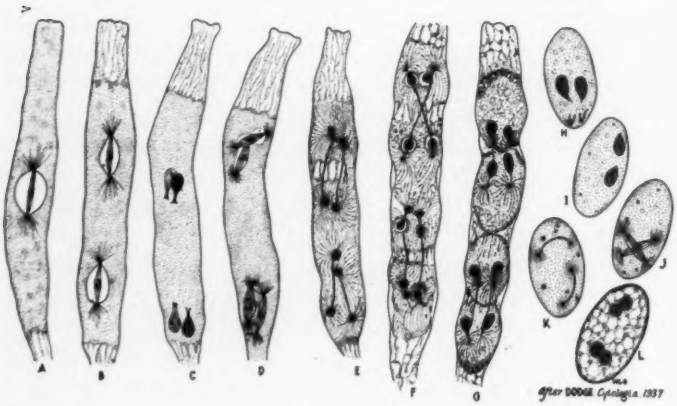

FIG. 1. *A–L*. Sketches showing nuclear behavior including conjugate nuclear division in connection with spore formation in *Gelasinospora tetrasperma*.

provided with four nuclei, *L*, four sets of chromosomes, so it must be "tetraploid." At spore germination the germ tubes and mycelial cells are given several nuclei each and so must be "polyploid!"

In one respect *Neurospora tetrasperma* gives us a more perfect conjugate division of the first pair of conjugate nuclei reorganized after reduction, figure *2*, *4*, because the two spindles most commonly lie close together and parallel. That all these divisions normally must be conjugate and thus serve a very definite end, is evident if we look at ascus *14*, which shows that if the spindles diverge widely two small spores which have only a single haploid nucleus each are cut out. Some spores are therefore haploid, and according to the new system, others "diploid," depending on how many sets of chromosomes the cell contains, this regardless of

whether the sets are included within a single membrane, or each set is in its own membrane.

How much simpler and clear it would all be to use the old well tried terms uninucleate, binucleate or dicaryotic, multinucleate, haploid, diploid, polyploid in the usual way and avoid utter confusion.

The fusion nucleus in the ascus is the zygote, the ascus being at this time diploid and a mother cell, it may also be called a zygote. The cells from which the acus arises, cells of the ascogenous hyphae, are not zygotes. No other cells in the ascocarp or in the mycelium

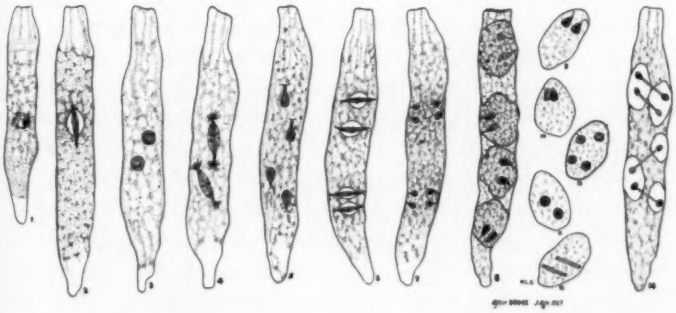

FIG. 2. 1–14. Diagrams showing spindle orientation in conjugate nuclear division in *Neurospora tetrasperma*. In ascus 14 the dotted lines connecting the nuclei in the spores simply indicate the original location of the spindles. See text for fuller description.

are zygotes. Their nuclei are not zygotes, therefore such cells and nuclei can not be *heterozygotes* or *heterozygous*. The fusion nucleus in the basidium of basidiomycetes is the zygote and we may say the mature basidial cell is a zygote cell. The cells from which basidia arise are not zygotes, their nuclei are haploid and not zygotes. The cells of the dicaryon are not zygotes. Therefore, such cells and such nuclei could not be heterozygotes or heterozygous, but the cells could very well be *heterocaryotic*.

The writer has pointed out on a number of occasions, particularly in a paper, now a long time in press, that the dicaryotic phase of the basidiomycetes is a highly interesting and important one, in that it gives us the opportunity in many cases to study the effects of genes as they are included in pairs of haploid nuclei, dicaryons, as contrasted with the effects of a single set of the same genes working

alone in uninucleate cells. In forms with multinucleate cells, such as *Neurospora* we may study homocaryotic as contrasted with heterocaryotic conditions. Growth from uninucleate microconidia and tertiary conidia is very slow at first as compared with growth from the large multinucleate conidia or hyphal fragments which is very rapid. Dickson reported in 1934 that dicaryons of his *Coprinus* always grew faster than did the individual components grown alone. The writer has, in a recent paper, shown that different sets of genes included in different nuclear membranes but in the same cytoplasm may act independently or in a complementary or supplementary way. It was assumed as an hypothesis that growth substances synthesized by one of the components supplement the growth substances synthesized by the other component, or components, to provide an optimum or full quota of growth substances necessary for vigorous growth. It was pointed out that heterocaryotic vigor, true hybrid vigor and individual vigor may be due to exactly the same or similar causes. Nevertheless they should be distinguished. True hybrid vigor, positive heterosis, is manifested in connection with structures in which the nuclei are diploid, that is, each nucleus contains a double number of chromosomes, two different sets. Heterocaryotic vigor, effects of heterocaryosis, if operating, is manifested in structures containing two or more kinds of haploid nuclei; dicaryotic vigor would express very beautifully the situation where the inclusion of two haploid components in a common cytoplasm, each synthesizing growth substances supplementing those made by the other component, results in the development of a mycelium which is more vigorous in growth than that of either of the haploid components.

By actually crossing a dwarf race with a more normal race, new haploid progeny were obtained. Through a fortuitous recombination of genes, these new homocaryotic races were able to synthesize a full quota of the necessary growth substances and so grew just as vigorously alone as did the heterocaryotic mycelium made up of the two original haploid parent components. It must be obvious to all that to call these new haploid progeny hybrids which showed hybrid vigor would be very incorrect and misleading.

If we introduce nuclei that carry genes for conidia into cells of a non-conidial race or vice-versa and find that the heterocaryotic

mycelium produces conidia, the question as to whether we may say that the factors for conidia are dominant to their alleles may be a purely academic one. On first consideration it would seem of little consequence. The important thing is to learn that the genes do act so independently. Many conidia are actually cut off the nuclei of which do not carry the genes favoring formation of conidia. Unpublished results of experiments on this problem have convinced the writer that we should still continue to say that Mendelian dominance is expressed in connection with diploid structures, yet be alert to discover just how and why heterocaryotic growth is determined by the nature of the genes included in the various nuclear components acting independently or coöperatively. Heterocaryotic vigor represents one of the effects obtained when two or more nuclei which differ genetically are working in a common cytoplasm. The effects of heterocaryosis may include color formation, change in rate and type of growth and the production of conidia or other morphological entities. They may be positive, resulting in heterocaryotic vigor, intensification of color, increased formation of conidia and other structures; or they may be negative, resulting in partial or complete inhibition of one or more of the characters of the component strains. Heterocaryotic vigor differs from heterosis in that the latter always implies a preceding fusion of unlike nuclei.

NEW YORK BOTANICAL GARDEN

INDIAN AND BURMAN SPECIES OF THE GENERA PESTALOTIA AND MONOCHAETIA

B. B. Mundkur and K. F. Kheswalla

The specimens of *Pestalotia* and *Monochaetia* on which this report is based were collected by E. J. Butler and his colleagues over a period of nearly twenty years in different parts of India and Burma. Six of these have been recorded by Butler and Bisby (**1931**) and three by Mundkur (**1938**) bringing the total for India and Burma to nine species. A study of the collections, some of which are not in a first class condition, has shown that the total number of species of *Pestalotia* occurring in these two countries is twenty-nine and there are two imperfectly determined specimens. Two species of *Monochaetia* are recorded here for the first time.

Two hundred and seventy-one species of *Pestalotia* are recorded in Saccardo's "Sylloge Fungorum" and the taxonomy of some of them has been investigated by Klebahn (**1914**) and Guba (**1929, 1932**). A monographic treatment of the genus based on an examination of the *types* seems desirable and until such a study is made, confusion in the classification of this genus with very imperfect type descriptions will continue to exist.

In the differentiation of species of both the genera much emphasis is laid on the characters of the conidia and the fruiting structures; there has been, however, considerable controversy with regard to the latter. Free spores on mycelial threads, spores in open acervuli, spores in acervuli covered by a pseudo-parenchyma (pseudopycnidium) and spores in true pycnidia have been reported. That true pycnidia are formed in *P. palmarum* and *P. Guepini* is evident from the cultural work carried out by Archer (**1926**). It is therefore manifest that the fructification may be either an acervulus or a pycnidium in this genus.

The material available for study was very brittle and had to be softened before sections could be cut. For this purpose, it was placed in a mixture of equal parts of sixty-five per cent alcohol and

pure glycerine and placed in an oven at 60° C. for twenty-four hours. This treatment helped considerably in softening it.

PESTALOTIA de Notaris, Mem. R. Accad, Torino, p. 80

1. PESTALOTIA MANGIFERAE P. Henn. Ann. Mus. Congo Belge V. Fasc. II. 120. 1907; Sacc. Syll. Fung. **22**: 1223. 1913.
   Syn. *P. funerea* Desm. forma *Mangiferae* Sacc. (Uppal, Patel & Kamat, **1935**, p. 27.)
   P. virgatula Kleb. Mykol. Zbl. **4**: 13. 1914 (Guba, **1929**, p. 222; Mundkur, **1938**, p. 40.)
   P. pauciseta Sydow (nec. Saccardo) Ann. Myc. **15**: 262. 1917.

On living leaves of *Mangifera indica* L. Poona, 22–8–1903 (E. J. Butler); Dehra Dun, 16–12–1903 (E. J. B.); Pusa, 19–4–1904 (E. J. B.); Suri-Birbhum (Bengal), 30–12–1905 (S. K. Basu); Chittagong, 15–8–1908 (R. Sen); Port Blair (Andamans), 31–1–1927 (M. Mitra and M. Taslim); Sabour, 4–10–1937.

2. PESTALOTIA GOSSYPII Hori ex S. Thuruda, Jl. Pl. Prot. p. 27. 1917. (Tanaka, **1919**, p. 154) Sacc. Syll. Fung. **25**: 603. 1931.

On living leaves of *Gossypium* sp. Aligarh, 9–9–1908 (Parr).

3. PESTALOTIA LEPROLEGNA Speg. Ann. Mus. Nac. Buenos Aires **23**: 119. (Guba, **1929**, p. 216.) Sacc. Syll. Fung. **25**: 1604. 1931. (Mundkur, **1938**, p. 40.)

On living leaves of *Musa sapientum* L. Dhalghat, Chittagong, 7–12–1907 (R. Sen). Also reported from Bombay. Spegazzini's fungus was on the skins of mature fruits; the present collection is on leaves but agrees with the description of *P. leprolegna* given by Spegazzini (**1912**).

4. PESTALOTIA MENEZESIANA Bres. & Torrend, Broteria p. 142. 1909; Sacc. Syll. Fung. **22**: 1223. 1913.

On living leaves of *Leea* sp. Sirsi, Bombay, October 1919 (L. J. Sedgwick).

5. PESTALOTIA MALORUM Elenkin & Chi, Z. Bolezni Rastenii p. 94. 1912; Sacc. Syll. Fung. **25**: 605. 1931.

On living leaves of *Pyrus Malus* L. Maymyo, Burma, 18–1–1908 (E. J. B.).

6. PESTALOTIA MICHENERI Guba, Mycologia **24**: 371. 1932.

On living leaves of *Araucaria* sp. Darjeeling, 27–8–1909 (Hafiz Khan).

7. **Pestalotia Taslimiana** sp. nov.

Acervuli, atri, minuti, plurimi, primo gregarii denique confluentes, subepidermales, erumpentes, foliis utrimque dispositi. Conidii fusiformia, erecta, apices versus fastigiata, 5-locellata, 14.3–20.9 × 4.5–6.6 μ, ex brunneo subnigra; cellula medianae 11.1–18.5 × 3.7–7.7 μ (med. 14.8 × 6.4 μ); cellula media 3.7–5.5 × 3.7–7.4 μ (med. 4.1 × 6.4 μ) cellula terminalis longa setis 3 vel rarius 4, 8–12 μ longis, modice divergentibus, ornata; cellula basalis acuta, in rostellum caudatum extensa.

Hab. in Calamo sp. Chittagong or. 15–12–1907, Typus (No. 2250 ex Herb. Crypt. Ind. Orient.); Pusa, 24–8–1916 (M. Taslim).

Acervuli black, numerous, at first gregarious later coalescing, minute, sub-epidermal, erumpent, on both sides of the leaves. Conidia fusiform, erect, tapering at the ends, 5-celled, 14.3–20.9 × 4.5–6.6 μ, median cell 11.1–18.5 × 3.7–7.7 μ (mean 14.8 × 6.4 μ); middle cells 3.7–5.5 × 3.7–7.7 μ (mean 4.1 × 6.4 μ) umber to dark brown; apical cell long, with 3 rarely 4 setae, 8–12 μ long, moderately divergent; basal cell acute with a caudate process.

On *Calamus* sp. Chittagong, 15–12–1907, Type (No. 2250 of Herb. Crypt. Ind. Orient.); deposited in Herb. Crypt. Ind. Orient., Herbarium.

This species differs from others reported on the order Palmae by its larger spores, characteristic basal cell with its caudate process, and in the fruiting structure being an acervulus.

8. PESTALOTIA LONGI-ARISTATA Maublanc, Bull. Soc. Myc. Fr.: 92. 1905; Sacc. Syll. Fung. **25**: 603. 1931.

On living leaves of *Eriobotrya japonica* Lindl., Dehra Dun, 2–10–1905 (E. J. B.).

9. PESTALOTIA ELASTICOLA P. Henn. Hedwigia **48**: 16. 1909; Sacc. Syll. Fung. **25**: 603. 1931.

On living leaves of *Ficus elastica* Roxb. Badamtam (Darjeeling) 2–9–1909 (W. McRae); on leaves of *Artocarpus integer* (Thumb.) Merr. (= *A. integrifolia* L. *f.*) Pusa, 1916 (E. J. B.).

10. PESTALOTIA VERSICOLOR Speg. Michelia: 479. 1879; Sacc. Syll. Fung. **3**: 790. 1884. (Klebahn, **1914**, p. 12; Guba, **1929**, p. 222.)

On leaves of *Carissa* sp. Karwar, Oct. 1919 (L. J. Sedgwick).

11. PESTALOTIA SAPOTAE P. Henn. Hedwigia **48**: 17. 1909; Sacc. Syll. Fung. **25**: 606. 1931.

On mature fruits of *Achras Sapota* L. Kirkee, 22–1–1937. Hennings reported the fungus on leaves but the Kirkee specimen was on the skins of mature fruits placed in cold storage.

12. PESTALOTIA PSIDII Pat. in Pat. & Lagerh. Bull. Soc. Myc. Fr.: 232. 1895; Sacc. Syll. Fung. **14**: 1025. 1899. (Guba, **1932**, p. 379; Mundkur, **1938**, p. 40.)

On fruits of *Psidium guyava* L. Dharwar, October 1907 (det. Patouillard); Mandalay, July 1915 (F. J. F. Shaw).

13. PESTALOTIA CLAVISPORA Atk. Bull. Cornell Univ. p. 37. 1897; Sacc. Syll. Fung. **14**: 1028. 1899. (Guba, **1932**, p. 363.)

On the upper surface of the living leaves of *Quercus incana* Roxb. Mussoorie, 9–9–1914 (P. C. Kar).

14. PESTALOTIA MANGALORICA Thüm. Rev. Myc. p. 37. 1880. Sacc. Syll. Fung. **3**: 790. 1884. (Butler & Bisby, **1931**, p. 159.)

On living leaves of *Bridelia stipularis* Bl. (= *B. scandens* Willd.), North Kanara Dt., October 1919 (L. J. Sedgwick). The type of this species on *Bridelia scandens* Willd. collected by Keck

at Mangalore is not available in India. A specimen of *Pestalotia* on leaves of *Mallotus* sp. collected by T. F. Chipps at Penang (Malaya peninsula) on 3–8–1919 is the same species.

15. **Pestalotia Citri** sp. nov.

Acervuli minuti, punctiformis, atri, in magnis maculis pallidis marginibus prominentibus dispositi. Conidia 5-locellata; cellulae terminales hyalinae, fastigiatae, fusiformis, 10.1–19.3 × 5.0–5.5 μ; cellulae media guttulatae, fuscae vel olivaceae, 6.8–14.3 μ longae, septis haud constrictae; setae 3 vel 4, 10–19.5 μ longae, divergentes, haud ramosae.

Hab. in foliis vivis *Citri grandis* Osbeck (= *C. decumana* L. p.p.). Kirkee 11–8–1914 (H. M. Chibber), Typus, No. 2209 Herb. Crypt. Ind. Orient.

Acervuli minute dot-like, black, seated on large bleached spots with raised edges; conidia 5-celled, end cells hyaline, tapering, 10.1–19.3 × 5.0–5.5 μ; median cells guttulate, umber to olivaceous, 6.8–14.3 μ long; not constricted at septa; setae 3 to 4, each 10 to 19.5 μ long, divergent, unbranched.

On living leaves of *Citrus grandis* Osbeck (= *C. decumana* L. p.p.). Kirkee, 11–8–1914 (H. M. Chibber). Type No. *2209* of Herb. Crypt. Ind. Orient. Also deposited in the Herbarium of the Imperial Mycological Institute, Kew.

16. PESTALOTIA BANKSIANA Cavara, Atti Ist. Bot. Univ. Pavia p. 435. 1888; Sacc. Syll. Fung. **10**: 489. 1892.

On leaves of *Grevillea robusta* A. Cunn. Vayitri, Calicut, 9–9–1904 (E. J. B.).

17. PESTALOTIA ALBO-MACULANS P. Henn. Hedwigia **43**: 94. 1904; Sacc. Syll. Fung. **18**: 480. 1906.

On living leaves of *Flemmingia* sp. Ballahari, Kamrup, 29–7–1912 (M. Taslim).

18. PESTALOTIA SUFFOCATA Ellis & Ev. Jour. Myc. **2**: 38. 1886; Sacc. Syll. Fung. **10**: 485. 1892.

On stems of *Rosa* sp. Pusa, 11–6–1916 (R. Sen).

19. PESTALOTIA GUEPINI Desmaz. Ann. Sci. Nat. II. **13**: 183. 1840; Sacc. Syll. Fung. **3**: 794. 1884. (Klebahn, **1914**, p. 7; Guba, **1929**, p. 198.)

On living leaves of *Hevea* sp. Port Blair (Andaman Islands), Feb. 1927 (M. Mitra). The *Pestalotia* on *Hevea* sp. is considered by La Rue (**1922**) to be *P. Guepini* but Petch (**1921**) considers it to be *P. palmarum* Cooke. Placed in this species tentatively.

20. PESTALOTIA THEAE Sawada, Spec. Rep. Agr. Exp. Sta. Taiwan p. 113. 1915. (Tanaka, **1917**, p. 171.) Sacc. Syll. Fung. **25**: 607. 1931. (Butler, **1918**, p. 451; Butler & Bisby, **1931**, p. 159.)

On living leaves of *Camillia sinensis* L. Bisnath (Assam), 8–8–1898 (Watt); Darjeeling, 15–7–1909 (W. McRae); Wyanaad, Malabar, 18–11–1909 (W. McRae); Port Blair (Andamans) 7–2–1927 (M. Mitra and M. Taslim).

21. PESTALOTIA PAUCISETA Sacc. Ann. Myc. **12**: 311. 1914; Sacc. Syll. Fung. **25**: 608. 1931.

On living leaves of *Litchi chinensis* Sonner (= *Nephelium Litchi* Camb.). Pusa, 4–4–1907 (Inayat Khan).

22. PESTALOTIA MACROTRICHA Klebahn, Mykol. Zbl. p. 6. 1914; Sacc. Syll. Fung. **25**: 601. 1931. (Guba, **1929**, p. 214.)

On living leaves of *Rhododendron campanulatum* Don. Ranikhet (Kumaon), 2–5–1907 (E. J. Butler).

23. PESTALOTIA FUNEREA Desmaz. Ann. Sci. Nat. p. 335. 1843. (Klebahn, **1914**, p. 5; Guba, **1929**, p. 202; Sydow & Butler, **1916**, p. 220; Butler & Bisby, **1931**, p. 159.)

On living leaves of *Cunninghamia sinensis* R. Br. Dehra Dun, 8–4–1904 (E. J. B.); on leaves of *Cupressus sempervirens* L., South India (date of collection and name of collector not stated).

24. PESTALOTIA LEPIDOSPERMATIS P. Henn. Hedwigia **40**: 355. 1901; Sacc. Syll. Fung. **18**: 484. 1906.

On leaves, leaf-sheaths and also culms of *Fuirena* sp. Maymyo (Burma) 19–1–1908 (Inayat).

25. **Pestalotia pipericola** sp. nov.

Pseudopycnidia 40–137 μ diametro, globosa, numerosa, epiphylla, sparsa, primo subepidermalia, deinde per cutem erumpentia, maculis mortuis cinereis sine margine finito disposita. Conidia 5-cellulata, recta vel nonnihil curvata, media parte tumescentia, 16.6–25.9 μ; cellulae medianae 3, ex nigro subbrunneae, 11.1–18.5 × 5.5–11.1 μ; med. cellula 3.7–7.4 × 3.5–15.5 μ; pedicellus filiformis. Setae 3, raro 2, unaquaeque cum aliis angulo obtuso disposita.

Hab. in foliis Piperi nigri L. Wynaad, Malabar, 1909 (leg. W. McRae), No. *2244* (Typus).

Pseudopycnidia 40–137 μ in diameter, globose or subglobose, numerous, epiphyllous, scattered, at first subepidermal, later bursting through the epidermis, erumpent, seated on ashen grey dead areas without a definite margin. Conidia five-celled, straight or slightly curved, bulged in the middle, 16.6–25.9 μ; median cells three, dark brown, 11.1–18.5 × 5.5–11.1 μ; middle cell 3.7–7.4 × 3.5–11.5 μ; pedicel filiform. Setae three, rarely two, at sub-obtuse angle to each other.

On leaves on *Piper nigrum* L. Wynaad, Malabar, 1909 (leg. W. McRae), No. *2244* (type).

Type deposited in the Herb. Crypt. Ind. Orient., New Delhi.

26. PESTALOTIA PALMARUM Cooke, Grevillea **3**: 115. 1875; **4**: 102. 1876; Sacc. Syll. Fung. **3**: 796. 1884 (Klebahn, **1914**, p. 9; Guba, **1929**, p. 210; Butler & Bisby, **1931**, p. 159).

Syn. *P. Phoenicis* Vize, Grevillea **4**: 14. 1876. (Butler & Bisby, **1931**, p. 159.)

P. brevipes Prillieux & Delacroix, Bull. Soc. Myc. Fr. p. 788. 1895 (non Cooke).

P. palmicola Sacc. & Sydow, in Sacc. Syll. Fung. **14**: 1030. 1899.

P. pinnarum Butler, nomen nudum. (Uppal, Patel & Kamat, **1935**, p. 28.)

On living leaves of the following hosts:

Areca catechu L. Chittagong, 19–12–1907 (R. Sen).

Borassus flabellifer L. Godagiri (Bengal), 31–8–1905; Suri Birbhum (Bengal), 30–12–1905 (Basu); Harpur (Bihar), 28–11–1921 (Taslim).

Cocos nucifera L. Tellicherry, 26-9-1904 (E. J. B.); Rangpur, 22-9-1908 (Hafiz Khan); Chaumuhani (Bengal) 6-12-1911 (E. J. B.); Port Blaid (Andaman Islands), 31-12-1927 (M. Taslim).

Phoenix sylvestris Roxb. Wasai (Bombay) 3-11-1902 (I. H. Burkill); Jalay (Bihar) Dec. 1915 (M. Taslim).

Phoenix sp. Pusa, 16-5-1905 (E. J. B.); Chittagong, 16-12-1925 (R. Sen). Palm. Dehra Dun, 1-7-1903 (E. J. B.).

27. **Pestalotia Lawsoniae** sp. nov.

Maculae numerosae superne, plerumque rotundae, aliquando in macular irregulares pallide brunneas aliquae coalescentes. Acervuli amphigeni, nigri, erumpentes, 54–96 μ diametro. Conidia fusiformia vel cymbiformia, 5-cellularia; tres medianae cellulae septo constrictae, cellulae brunneae 11.1–14.8 × 3.7–7.5 μ, cellula media 3.7–5.5 × 3.7–7.4 μ. Setae 2, 8 to 21 μ, late divergentes.

Hab. in foliis Lawsoniae albae Lamk. Pusa, 19-10-1906, leg. Inayat Khan (Typus).

Spots numerous, circular, some coalescing into whitish to light brown patches. Acervuli black, subepidermal, amphigenous, erumpent, minute, 54–96 μ in diameter. Conidia five-celled, fusiform to elliptic, fusoid, usually erect, constricted at septa, 14.8–25.9 μ; median cells three, olivaceous, equally coloured, 11.1–14.8 × 3.7–7.4 μ; middle cell 3.7–5.5 × 3.7–7.4 μ. Setae 2, 8 to 21 μ, widely divergent.

On leaves of *Lawsonia alba* Lamk. Pusa, 19-10-1906 (leg. Inayat Khan) (type). Type deposited in the Herb. Crypt. Ind. Orient. New Delhi.

MONOCHAETIA Sacc. Syll. Fung. **18**: 485. 1906.
(As a sub-genus, Sacc. Syll. Fung. **3**: 798. 1884.)

28. MONOCHAETIA MALI (Ellis & Ev.) Sacc. & D. Sacc. Syll. Fung. **18**: 485. 1906.
Syn. *Pestalotia Mali* Ellis & Ev. Jour. Myc. **8**: 13. 1902.

On living and blighted leaves of *Pyrus Malus* L. Almora (Kumaon), 3-10-1919 (S. D. Joshi).

29. MONOCHAETIA DEPAZEOIDES (Otth) Sacc. Syll. Fung. **18**: 485. 1906.

Syn. *Pestalotia depazeoides* Otth, Mitt. Naturf. Ges. Bern p. 68. 1868.

On living leaves of *Rosa moschata* L. Achibal (Kashmir), 20–8–1908 (E. J. B.).

IMPERFECTLY DETERMINED SPECIES

30. PESTALOTIA sp.

On living leaves of *Terminalis paniculata* Roth. Sirsi (North Kanara), Oct. 1919 (L. J. Sedgwick). Spores measured in 1919 were found to be 13.2–22 × 4.4–8.8 μ. At present all mature spores have fallen off and it is not possible to identify the fungus.

31. PESTALOTIA sp.

On living leaves of *Eucalyptus globulus* Labill. at Coonoor (Nilgiris), 1917 (McRae). McRae (**1917**) placed the fungus in *Pestalotia funerea* but this species is now restricted to the Coniferae. There are four species on *Eucalyptus* but it is not possible to determine this fungus correctly for want of mature spores.

SPECIES NOT SEEN OR AVAILABLE

32. PESTALOTIA FUSCESCENS Sorauer, Pflanzenkrankh. 2a. ed. II, 1886, 399–400. (Butler & Bisby, **1931**, p. 159.)

On young plants of *Livistona* (*Corypha*) *australis* R. Br. exported from India to Germany.

33. PESTALOTIA CAFFRA Sydow, Ann. Myc. **12**: 266. 1914. (Uppal, Patel & Kamat, **1935**, p. 27.)

On leaves of *Mimusops elengi* L. Dapoli (Bombay Presidency).

SUMMARY

This paper records the result of an investigation of the species of *Pestalotia* and *Monochaetia*, collected by E. J. Butler and his colleagues over a period of nearly twenty years in India and Burma. The investigation has shown that there are thirty-one species of

Pestalotia and two of *Monochaetia* in these two countries. Of the thirty-one species of *Pestalotia*, two were not available for examination, two were in a very imperfect state so that their specific determination could not be made. Of the rest, four are proposed as new species: *P. Taslimiana*, *P. Citri*, *P. pipericola* and *P. Lawsoniae*.

We wish to express our gratitude to Dr. N. L. Bor, Forest Botanist, Dehra Dun, for his kindness in translating the diagnoses of the new species into latin.

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REFERENCES

Archer, W. A. 1926. Morphological characters of some Sphaeropsidales in culture. Ann. Myc. **24**: 1–84.

Butler, E. J. 1918. Fungi and disease in plants. Calcutta. VI + 547 pp. *206 figs.*

Butler, E. J. & Bisby, G. R. 1931. The Fungi of India. Sci. Monogr. Counc. Agr. Res. India, 1, 159 pp.

Guba, E. F. 1929. Monograph of the genus *Pestalotia* de Notaris. Phytopathology **19**: 191–232.

——. 1932. Monograph of the genus *Pestalotia*. Mycologia **24**: 355–397.

Klebahn, H. 1914. Beiträge zur Kenntnis der Fungi Imperfecti. Zur Kritik einiger *Pestalozzia*-Arten. Mykol. Zbl. **4**: 1–19.

McRae, W. 1917. Notes on South Indian Fungi. Madras Agr. Dept. Year Book, **1917**: 108–111.

Mundkur, B. B. 1938. Fungi of India, Supplement I. Sci. Monogr. Counc. Agr. Res. India. 12.

Sydow, H. and P. & Butler, E. J. 1916. Fungi Indiae Orientalis. Ann. Myc. **14**: 177–220.

Tanaka, T. 1917. New Japanese fungi. Notes and translations: I. Mycologia **9**: 167–172.

——. 1919. New Japanese fungi. Notes and translations: VII. Mycologia **11**: 148–154.

Uppal, B. N., Patel, M. K. & Kamat, M. N. 1935. The Fungi of Bombay. VIII + 56 pp.

ELSINOË IN UGANDA

ANNA E. JENKINS AND A. A. BITANCOURT

(WITH 1 FIGURE)

Uganda has proved a rich collecting ground for species of *Elsinoë* (**4**) as shown by Hansford's (**3**) description of seven new species from that region, together with mention of several other species also found there. Among the latter group are *E. Canvaliae* Rac.? on *Dolichos lablab,* recently described as a distinct species, *E. Dolichi,* by Jenkins, Bitancourt and Cheo (**5**), *E. Fawcetti* Bitancourt and Jenkins (**1**) on *Citrus,* and *E. Tephrosiae* Hansford (**2**) on *Tephrosia candida.*

The new species described are *E. Piperis* on *Piper capense* (*Piperaceae*); *E. Adeniae; E. antiaridis* and *E. Urerae* on *Adenia* sp., *Antiaridis toxicaria,* and *Urera camerunense,* respectively, of the *Urticaceae; E. Pseudospondiadis* on *Pseudospondias microcarpa* (*Anacardiaceae*), *E. Tylophorae* on *Tylophora* sp. (*Asclepidaceae*) and *E. Chandleri* on *Mikania scandens* (*Compositae*). In addition *Elsinoë* sp. is reported on *Stereospermum kunthianum.* Specimens of these seven new species with the exception of *E. Tylophorae* were contributed to the writers by Hansford before the descriptions were published and they are filed in the Mycological Collections of the Bureau of Plant Industry and in the Secção Fitopatologia, Instituto Biologico, São Paulo, Brazil.

Upon discovering still another species of *Elsinoë* in Uganda in September 1940, Hansford sent an ample gathering of this to the writers with the request that they prepare the diagnosis. In recognition of Hansford's notable discoveries of fungi of this pathogenic group in Uganda this species will be designated in his honor. The description follows:

FIG. 1. *Elsinoë Hansfordii* on *Scutia myrtina* Kurz., Uganda, September 1940, C. G. Hansford *2819. A,* Infected leaves, lower surface, XI; *B,* Enlarged scabs, × 12; *C,* Section through an ascoma, × 500. Photographs by M. L. F. Foubert (*A* and *B*) and by Bitancourt (*C*).

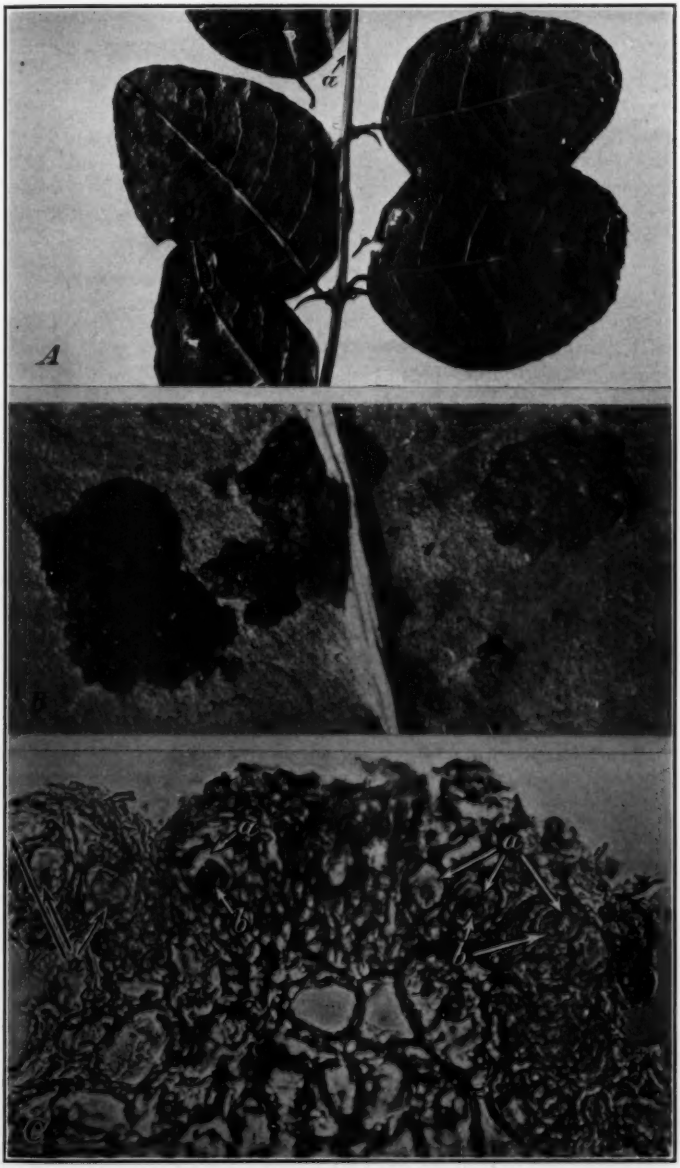

FIG. 1.

Elsinoë Hansfordii sp. nov. (FIG. 1).

Scabs hypophyllous (where scabs have been eaten by insects, a light spotting on upper leaf surface), prominent, distinct from the surrounding healthy tissue of the leaf, roundish or irregular, with rough uneven surface, sayal brown (6), light seal brown (6), or, when densely covered with ascomata, nearly black, 0.2 mm.–3 mm. in diam., hyperplastic scab well delimited from the healthy tissues of the leaf by a well developed generating layer, cells of outer part of hyperplastic tissue more or less filled with gum; ascomata numerous on the surface of the scabs, scattered or densely crowded and almost coalescent, pulvinate or more or less globose; dark brown to black, sometimes almost completely covering the surface of the scab; as seen in cross section composed of a more or less homogenous hyaline, yellowish, or, more often, brown pseudoparenchyma, 75–150 μ in diam. by 60–100 μ thick, outermost cells slightly darker and thicker but not forming a well defined epithecium; asci scattered in one or two irregular layers in the pseudoparenchyma, thick walled, especially at the apex, 16–22 μ in diam., with up to 8 ascospores; ascospores hyaline, 1-septate (probably immature), with upper cell broader than the lower cell, 12–15 by 4–6 μ; hyaline oblong biguttulate conidia 5–8 by 2–3 μ, interpreted as those of the imperfect stage, present on the surface of the ascomata.

Verrucae hypophyllae, prominentes, brunneae, interdum ascomatibus dense tectae et fere nigrae, 0.2–3 mm. diam.; ascomata numerosa in superficie verrucarum dispersa vel dense conferta et fere coalescentia, pulvinata vel plus minusve globosa, nigro-brunnea usque nigra, interdum superficiam totam verrucae supertegentia, e pseudoparenchyma hyalina, flavidula vel saepius brunnea composita, 75–150 μ in diam., 60–100 μ crassa, cellulis externis crassioribus et obscurioribus sed epithecio definito absente; asci in stratis uno vel duobus pseudoparenchymatis conspersi, 16–22 μ in diam.; ascosporae hyalinae, uniseptatae (probabiliter immaturae), cellula superiore latiori, 12–15 μ longae, 4–6 μ lati; conidia hyalinia, oblonga, biguttulata, 5–8 μ longa, 2–3 μ lata, in superficie ascomatum praesentia; verisimiliter status imperfectus.

Distribution: On leaves and stems of *Scutia myrtina* Kurz. (Rhamnaceae), Uganda.

SPECIMEN EXAMINED: Kiterera, Busoga, Uganda, September 1940, C. G. Hansford *2819*. Part serving as the type divided between Mycological Collections of the Bureau of Plant Industry.

Washington, D. C. (No. *73727*) and Secção de Fitopatologia, Instituto Biologico, São Paulo, Brazil (No. *4123*).

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BIBLIOGRAPHY

1. **Bitancourt, A. A. & Jenkins, A. E.** *Elsinoë fawcetti*, the perfect stage of the citrus scab fungus. Phytopathology **26**: 393–396. 1936.
2. **Hansford, C. G.** *Elsinoë tephrosiae* Hansford sp. nov. *His* Annual Report of the plant pathologist 1936. Ann. Rept. Dept. Agr. Uganda Prot. **(1936)** (2): 49. 1938.
3. **Hansford, C. G.** Contributions towards the fungus flora of Uganda. III. Some Uganda Ascomycetes. Proc. Linn. Soc. London. 153rd Session **(1940–41)** Part 1: 4–52. 1941.
4. **Jenkins, A. E. & Bitancourt, A. A.** Revised descriptions of the genera *Elsinoë* and *Sphaceloma*. Mycologia **23**: 338–340. 1941.
5. —— **& Cheo, C. C.** Descriptions of *Elsinoë dolichi* n. sp. and *Sphaceloma ricini* n. sp. Jour. Wash. Acad. Sci. **31**: 415–417. 1941.
6. **Ridgway, R.** Color standards and color nomenclature. 43 pp. Washington, D. C. 1912.

A NEW YELLOW LEPIOTA

VERA K. CHARLES

The fungus described in this paper was found in an orange grove near Orlando, Fla., during January 1941. Attention was attracted to it because of its bright orange color which rendered it conspicuous against the dark background of the dead wood on which it was growing. Its resemblance to a miniature puff-ball was very striking, but with the aid of a hand lens the presence of gills could be discerned. Only two or three individuals were present on the piece of wood when collected but more developed later when the wood was placed in a damp chamber. Although additional pieces of wood in the near vicinity were examined no more specimens were found. In the early unexpanded stage before any appearance of stipe, the resemblance to *Lycoperdon gemmatum* was very marked, the only difference being in the color which in the fungus described here was orange-yellow instead of white as in *Lycoperdon gemmatum*.

The generic position of the fungus was puzzling as the characters are not clearly typical of any one genus. A cobwebby ring is present in the young condition but is evanescent and soon disappears. The hymenophore is not definitely discrete as in most species of *Lepiota* and the gills are adnate, which, however, is true in certain species of *Lepiota*.

A search was made of the literature, including newly described species of *Lepiota*, both North American and tropical, but no species was found which agreed with the Florida collection. Beeli [1] in his work on "Champignons du Congo" described several yellow species but none agree both macroscopically and microscopically with the fungus discussed here. *Lepiota gemmata* described by

[1] **Beeli, M.** Flore Iconographique des Champignons du Congo, fasc. 2, Brussels 1936.

FIG. 1. *Lepiota aurantiogemmata*. *A*, two mature plants and small undeveloped specimen shown enlarged in *B*, nat. size; *B*, early stage showing arachnoid ring, × 10.

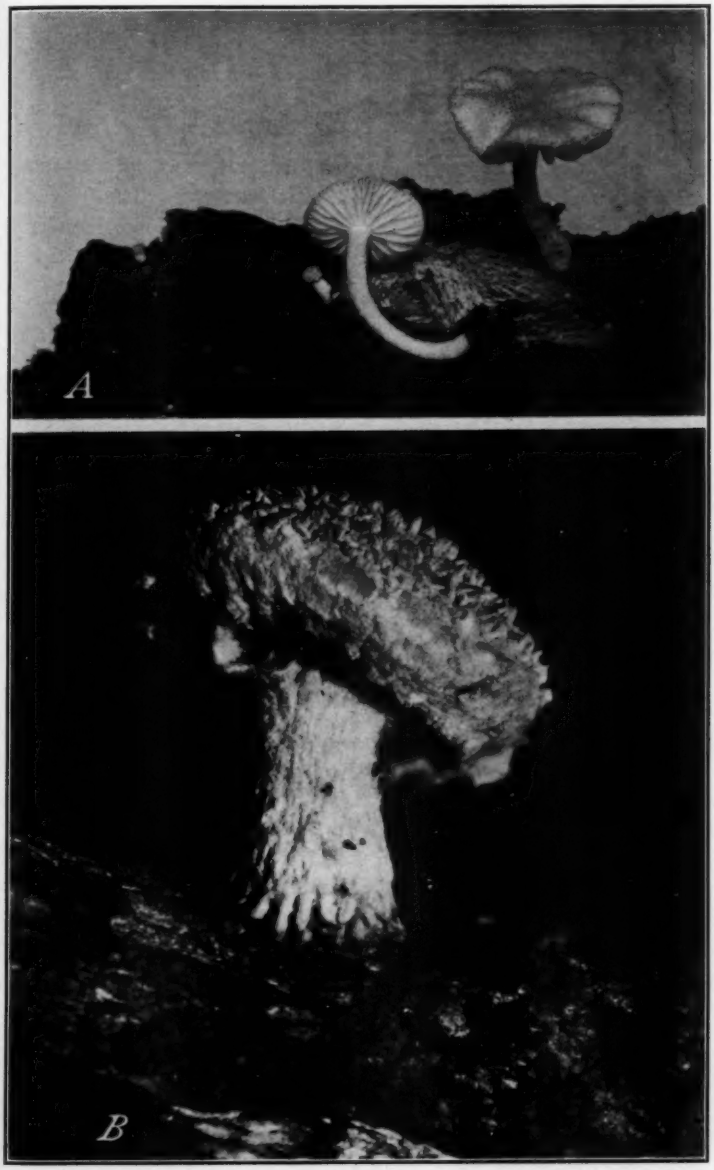


FIG. 1.

Morgan and so-called because of its resemblance to *Lycoperdon gemmatum* in the undeveloped stages was compared but in addition to the difference in color, *Lepiota gemmata* being white, there is a difference in the gills and spores. *Lepiota scabrivelata* Murr. belonging to the section *Acutesquamosae* collected at New Orleans, La., suggests the Florida material but is paler in color, has an ample though not persistent ring and smaller spores. The fungus discussed here is considered new and described as follows under the name of *L. aurantiogemmata* a reference to the color and shape of the pileus.

Lepiota aurantiogemmata Charles & Burlingham sp. nov.

Pileo 1.5–2.5 cm. lato, aurantiaco-luteo, tomentoso, tomento ex fibris in caespites pyramidatos aggregatis, composito, margine involuto fibrilloso: cortina arachnoidea supera, fibrillosa, fugaci: lamellis albidis, denum pallide flavis, adnatis, inaequalibus, subdistantibus: stipite 2–2.5 cm. longo, 1.5–2 mm. lato, flocculoso-squamoso, peronato: sporis apiculatis, subglobosis v. avoideis 6.25–6.85 × 8.75 μ, reticulatis: cystidiis paucis, crasse tunicatis, 34–38 μ longis, lageniformibus, apice subcoronatis.

Hab. ad lignum emortuum.

Pileus orange-yellow, 1.5–2.5 cm. broad, covered with orange-yellow tomentum, the fibers of which unite at the apex to form pyramidal clusters, margin at first incurved felty-tomentose; ring cobwebby, composed of fine fibers at the apex of the downy fibrous covering of the stem, evanescent; gills white, later pale yellow, adnate, unequal, rather distant: stipe 2–2.5 cm. long, 1.5–2 mm. in width, peronate with soft fibers: spores subsphaerical to oval, apiculate 6.25–6.85 × 8.75 μ, reticulate with iodine: cystidia few, large 34–38 μ projecting beyond the basidia, flaskshaped, apex thickened, slightly coronate.

Type collected on dead wood near Orlando, Fla., Jan. 25, 1941, G. S. Burlingham and V. K. Charles. Deposited in the Mycological Collections of the Bureau of Plant Industry, Washington, D. C. No. *71371*.

BUREAU OF PLANT INDUSTRY,
WASHINGTON, D. C.

THE INHERITANCE OF INDUCED MUTATIONS IN NEUROSPORA TETRASPERMA

WALTER SCOTT MALLOCH

Natural mutations have been studied in *Neurospora crassa* for nearly a decade (cf. Lindegren, **1932**, **1933**), but recently X-ray and ultra-violet induced mutations have been investigated in this species (cf. Lindegren & Lindegren, **1941**; Beadle & Tatum, **1941**). On the other hand, *N. tetrasperma* is more stable, so that it was more convenient, at first, to investigate those mutations which were the result of high frequency radiation (cf. Dodge, **1934**, **1935**, **1936**; Dodge & Seaver, **1938**; Malloch, **1941**). The nature of this evidence will be discussed before describing the genetic behavior of X-ray induced mutations in this species.

Dodge & Seaver (**1938**) studied a dominant factor, *I*, for indurated ascus abortion and a recessive factor, *d*, for deliquescent ascus abortion, which originated in an X-ray experiment. In the deliquescent or cytolytic type of abortion, the full quota of asci arise in the ascocarp and become elongated. Then without developing any spores, the asci disintegrate and disappear. In the second type of abortion, asci become chitinized or indurated, dark colored, and striated like the ascospores. Genetic studies could be carried beyond the first generation because some asci matured spores in every ascocarp.

Among the new alterations which have recently been described (cf. Dodge, **1939**, **1941**) a lethal form occurred in non-irradiated material. The lethal *E* was assumed to be a chromosomal deficiency, which either caused ascus abortion or prevented the germination of those ascospores carrying it. The fourth type was a bright cadmium-yellow dwarf race, which had a very low growth rate and was non-conidial (cf. Dodge, **1941**). When this mutation was crossed with another race the growth of the mycelium and conidiospores was increased manyfold.

Dodge (**1935**) and Tai (**1936**) reported that a factor *O* for salmon orange conidia was strongly linked with the sex factor *a*, and that a factor *o* for salmon pink conidia was linked with Sex *A*. Since these factors are studied to the best advantage in interspecific hybrids, the genetic formula in this investigation will not be complicated by the addition of these symbols. In addition Tai (**1936**) reported that a factor *M* for blackening of the substratum is strongly linked to the factor *A*. The color of the substratum was orange or amber in those cultures carrying factor *a*. While the behavior of culture No. 42 can be explained without the use of these symbols, an ascus analysis of dark and light X-rayed derivatives of this species suggested that these alterations were determined by genetic factors. In an investigation of a mating between *N. tetrasperma* and *N. sitophila* Dodge (**1936**) studied a pair of factors, *Cc*, for the presence and absence of conidia. Since the non-conidial character was introduced into the mating by *N. sitophila*, it is probably different from the brown mycelium type which was discovered in *N. tetrasperma* (cf. Malloch, in press).

It is the aim of this paper to discuss several genetic factors, which were briefly mentioned in two preliminary papers on high frequency radiation (cf. Malloch, **1940**, **1941**). With the exception, of *Aa*, we believe that the factors reported here differ from those previously reported. As a consequence, there is still no duplication in the symbols used for genetic factors in *N. tetrasperma*. The methods, which have been used in this investigation, have been selected from those already reported (cf. Goodspeed, **1942**; Lindegren, **1932**; Shear & Dodge, **1927**; Uber & Goddard, **1934**; Wuekler, **1935**), with the exception that ascus dissection was performed by hand with the aid of a flexible gold strip, 0.1 mm. in thickness. This instrument was flexible enough to cut the cluster of asci into several sections without shattering the individual members. The names for the color characters were adopted after comparing the different cultures with Ridgway's Color Standards (**1912**). Since we have described the genetic factors which are already known for this species the results of the present experiment will now be discussed.

DERIVATIVES OF ONE X-RAYED ASCOSPORE OF NEUROSPORA TETRASPERMA

When F_2 populations were grown from the derivatives of X-rayed ascospores of this species, some populations gave evidence of a heterozygous condition. The progeny of one culture, No. 42, attracted particular attention because of the distinctive type of segregation (cf. Malloch, **1941**). It was characterized by the absence of conidiospore production, by defective perithecia development, and by the production of a few ascospores. The diploid and haploid derivatives of this distinctive race exhibited several new character combinations. As indicated by the genetic evidence these character combinations are governed by three pairs of genes. An allelomorphic pair of factors, *Aa*, determine sex expression, *A* being associated with salmon pink (pale), and *a* with salmon orange conidiospore color. *W* and *w* are factors affecting the form of hyphal growth, *W* being a dominant factor for normal, and *w* being a recessive factor for a dwarf type of growth. The third pair of factors, *Pp*, affect several characters, *P*, being associated with normal perithecia and ascospore production and a chestnut brown (medium) color in the substratum, and *p* with reduced perithecia and ascospore production and a light color in the substratum. In the presence of *W*, factor *p* conditions fluffy conidiospore growth, but in the presence of *w*, conidiospore growth is distinctly reduced or absent. In this paper a series of letters, such as *aW p* is understood to represent a unisexual race, and a formula, such as $\frac{aW}{AW}\frac{P}{P}$, a bisexual strain. The following diploid and haploid types, which were derived from culture No. 42, were studied in this experiment.

I. The normal orange type. The aerial mycelium and conidial growth were loose and irregular at first but soon formed floccuse masses, which were salmon orange in color. A chestnut brown color developed in the sclerotia and surface mycelium as the culture reached maturity. Numerous hairy sclerotia were present, but perithecia were completely absent. This type has the genetic constitution *aW P*, because it has a normal rate of

growth (*W*), and because it is capable of forming normal perithecia (*P*) when mated with the standard Sex *A* strain.

II. The normal pale type was like the preceding, except that conidiospore production was reduced and salmon pink in color. It has the genetic constitution *AW P*, since the rate of growth is normal (*W*), and it forms normal perithecia (*P*) when mated with the standard Sex *a* strain.

III. The fluffy orange type. The aerial mycelium and conidial growth were exceptionally vigorous from the beginning, so that fluffy compact masses were formed, which gradually acquired a salmon orange tint. The clear substratum changed to orange upon reaching maturity. There were numerous colorless sclerotia, but perithecia were absent. It has the genetic constitution *aW p*, because the growth rate is normal (*W*) and the production of perithecia is reduced when mated with *Aw p*.

IV. The light dwarf type was distinguished by a very slow-growing mycelium with short branches. The few conidiospores which did develop were pale in color. Sclerotia and perithecia were lacking in this form. The genetic constitution of this type was *Aw p*, since it has a dwarf type of growth (*w*) and it produces a reduced number of perithecia when mated with the fluffy orange type, *aW p*.

V. The dark dwarf type was like the preceding, with the exception that it was darker in color. This strain has the genetic constitution *Aw P*, because it has a dwarf type of growth (*w*) and it produces perithecia (*P*) and ascospores when mated with *aW P*.

VI. The normal bisexual type. The conidial stage was identical with the normal orange type, but as the culture reached maturity it was characterized by normal perithecia and ascospore production. Since the *W* and *P* factors are dominant, this bisexual form could have any one of the following constitutions: $\frac{aW\ P}{AW\ P}, \frac{aW\ p}{AW\ P}, \frac{aW\ P}{AW\ p}, \frac{aW\ P}{Aw\ P}, \frac{aW\ p}{Aw\ P}, \frac{aW\ P}{Aw\ p}$.

VII. The light semi-fertile type. The conidial stage was identical with the fluffy orange type with the exception that the conidial mass was orange pink in color. In this respect this strain was intermediate between the salmon orange and salmon

pink colors of types I and II. The light semi-fertile type produced a few slow-developing perithecia with limited ascospore production. As will be shown later the genetic constitution of this form was $\frac{Aw\ p}{aW\ p}$.

Four additional types occurred among the progency of culture No. 42, but these will be described at a later date (cf. Malloch, in press).

THE GENETIC BEHAVIOR OF TYPES I TO VII

Certain of the unisexual types were crossed with the standard sex strains in order to determine which genes were present. As shown in Table 1, the light dwarf type (culture No. D_1) was

TABLE 1

F_2 PROGENY OBTAINED FROM ASCOSPORES WHICH HAD THE GENETIC CONSTITUTION $\frac{aW\ P}{Aw\ p}$

Number of experiment	$D_1 \times Ta$ $1\text{–}F_2$	Number of experiment	$D_1 \times Ta$		$D_{86} \times Ta$ $1\text{–}F_2$
			$1\text{–}F_2$	$2\text{–}F_2$	
Type of asci as shown by progeny		Progeny from spore print			
1.0 All normal	19	4.0 All normal	71	49	60
Unisexual types		5.0 Semifertile	23	13	18
1.1 $aW\ P$	6	6.0 Unisexual types			
1.2 $Aw\ p$		$aW\ P$	1	2	0
1.3 $Aw\ P$		$Aw\ p$	1	1	1
1.4 $aW\ p$		$Aw\ P$	1	0	0
2.0 Two normal :		$aW\ p$	2	0	2
3.0 two semifertile	18	Test for X^2	.0005	.0537	.0500
Unisexual types from normals		3 : 1 ratio P	.99–.98	.90–.80	.90–.80
2.1 $aW\ P$	2				
2.2 $Aw\ P$					
Unisexual types from semifertiles					
3.1 $aW\ p$	6				
3.2 $Aw\ p$					
Test for X_2	.0360				
3 : 1 ratio P	.90–.80				

crossed with the standard sex type (culture No. Ta). The different genotypes obtained from this cross are numbered for convenience of reference (cf. Table 1). Cultures derived from the mating $D_1 \times Ta$ produced two types of asci: those producing

four normal bisexual cultures (Table 1, No. 1.0), and those producing two normal bisexual (Table 1, No. 2.0) and two semi-fertile (Table 1, No. 3.0) cultures. The observed frequencies were 19 asci of the first type and 18 of the second, or a proportion of 112 cultures of the normal bisexual type to 36 cultures of the semi-fertile strain. When tested for a 3 : 1 ratio, the chi-square and probability values amounted to .0360 and .90–.80. When progenies were grown from a spore print (cf. Table 1), one population consisted of 71 cultures of the normal bisexual type, and 23 cultures of the semi-fertile type. When tested for the same ratio, the chi-square and *P* values were .0005 and .99–.98. Data in Table 1 show that other populations behaved in a similar fashion. Judging by the chi-square tests there is reason to believe that these characters segregate according to a 3 : 1 ratio. This ratio, however, is produced by a different method from that found in higher plants and animals.

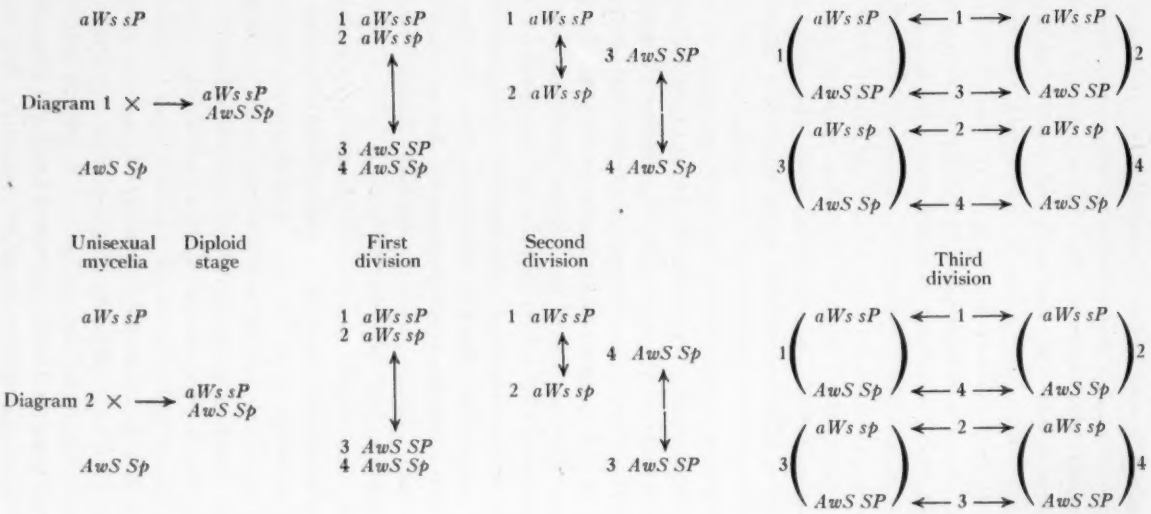
In order to explain the segregation of genetic characters in *Neurospora tetrasperma*, diagrams similar to those given by Lindegren (**1933**) and Dodge (**1936**) have been constructed. The chromosomes are represented by letters, such as *aWs sP*, for the known genetic factors. The spindle-fiber attachment of one member of a homologous pair of chromosomes is represented by *S* (or *S S*), and that of the second member by *s* (or *s s*). Crossing-over can be shown by means of these letters, but since the spindle-fiber attachment is probably inert, the segregation of these symbols can be neglected or omitted in the interpretation of the genotype.

The genetic constitution of the unisexual mycelia entering into a cross is indicated in the first vertical column, while the constitution of the diploid cell in the ascus hook is shown in the second column. The products resulting from segregation in the first division are shown in the third column. Lines 1 and 2 or 3 and 4 of the third column represent the two chromatids of a chromosome. The four chromatide have been numbered so that their behavior in the second and third divisions can be followed. The second and third divisions are shown in columns four and five respectively. In the diagram, the two non-sister nuclei which form a bisexual ascospore are enclosed by brackets. The

fourth division has been omitted from the diagram since it is an equational type. It is understood that the arrangement in the ascus is uniseriate at maturity, due to a turning and slipping of the spores as soon as they are finally cut out (cf. Dodge, **1927**). This arrangement of the spores in the ascus is represented by numbers on the outside of the brackets.

The correspondence between cytological and genetic behavior can be shown by considering the different types of segregation which are possible in a homothallic ascomycete. In the first place, we may consider the behavior of those factors which do not undergo crossing-over. This phenomenon does not occur when a factor is located close to the spindle-fiber attachment or when an inversion of the right dimension has taken place. The absence of crossing-over in the sex factors is indicated in Diagram 1 by continuing to place the *a* factors in the same chromatids with the *s* spindle-fiber attachment. It may be noted that any other factor, such as *W*, which is closely linked to *a* will segregate in the same way. As a consequence of this phenomenon and the fact that non-sister nuclei coöperate in spore formation, every spore will contain an *A* and *a* factor, and all of the resulting bisexual spores will appear alike. The constitution of the unisexual ascospores can be determined by considering each of the eight nuclei in the third division as a spore. In Diagram 1, for instance, the uninucleate ascospores could have any one of the following formulae: *aWs sP*, *aWs sP*, *AwS SP*, *AwS SP*, *aWs sp*, *aWs sp*, *AwS Sp*, *AwS Sp*.

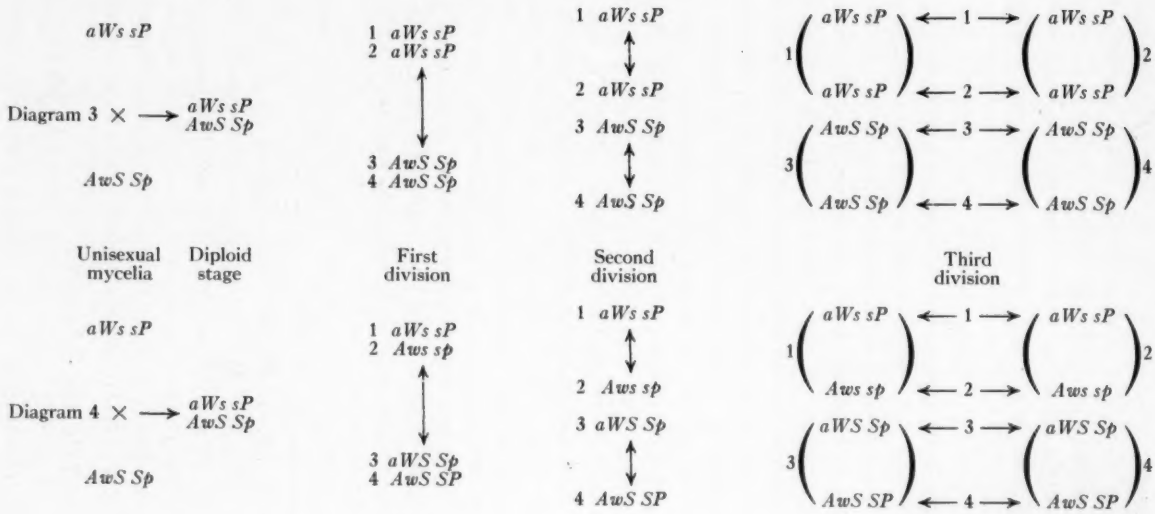
We may now consider the behavior of two factors, which are located upon separate chromosomes, assuming that crossing-over does not occur in either factor. Two types of first-division spindles can be obtained, since the second factor, *P*, may go to the same pole as the factor for Sex *a*, or to the same pole as the factor for Sex *A*. Due to the incorporation of non-sister nuclei in the same ascospore, all of the bisexual types would contain the same genetic factors, so that the segregation of genetic characters could not occur in these cultures. By constructing diagrams in which two factors, *a* and *p*, behave like the sex factors in Diagrams 1 and 2 it could be shown that different types of unisexual cultures would be obtained. For instance,


aWs sP
Diagram 1 ×
aWs sP
AwS Sp
AwS Sp
Unisexual mycelia
Diploid stage
aWs sP
Diagram 2 ×
aWs sP
AwS Sp
AwS Sp
1 aWs sP
2 aWs sp
3 AwS SP
4 AwS Sp
First division
1 aWs sP
2 aWs sp
3 AwS SP
4 AwS Sp
Second division
1 aWs sP
2 aWs sp
4 AwS Sp
3 AwS SP
Third division
1 aWs sP AwS SP 2 aWs sP AwS SP
3 aWs sp AwS Sp 4 aWs sp AwS Sp
1 aWs sP AwS Sp 2 aWs sP AwS Sp
3 aWs sp AwS SP 4 aWs sp AwS SP

when *p* goes to the same pole as *Aw*, the following haploid ascospores would be produced: light dwarf, *AwS Sp*, and the normal orange type, *aWs sP*. When *P* goes to the same pole as Sex *A*, the following types of unisexual ascospores should be obtained, the dark dwarf, *AwS sP*, and the fluffy orange type, *aWs Sp*.

The effect of crossing-over on the segregation of genetic characters in *N. tetrasperma* will now be considered. It will be assumed that the *Pp* factors show fifty per cent crossing-over with the spindle-fiber attachment, but that the *Aa* factors do not show this phenomenon. As shown by the diagrams, the spindles have an oblique arrangement in the second division. When the spindles are oriented in the same direction, two asci will be homozygous for *P*, and two will be homozygous for *p* (cf. Diagram 1). If the second spindle is just reversed from the first one, all of the ascospores will contain the factor pair *Pp* (cf. Diagram 2) and, hence, all of the resulting cultures should appear alike. Two other arrangements are possible in that each spindle may be reversed in both cases. For instance, the two spores which are homozygous for *P* may be in the blunt end of the ascus in one case and in the narrow end in the second case. When crossing-over occurs in one factor only, the same end result is obtained regardless of whether the two factors are located upon one or two chromosomes. Since the *Pp* factors are the only ones in which crossing-over occurs, it will be unnecessary to discuss double crossing-over until a later date (cf. Malloch, in press).

Since it is known from cytological studies that the spindles may sometimes have a longitudinal arrangement in the second division (cf. Dodge, **1927**, **1936**), instead of the oblique type shown in Diagrams 1 and 2, it is necessary to consider the genetic effect of such an arrangement. We will discuss a case in which two factors are located upon different chromosomes of this species. When *p* goes to the same pole of the spindle as *A*, assuming that no crossing-over occurs, the four ascospores would have the following constitution, $\frac{aWs}{aWs}\,\frac{sP}{sP}$, $\frac{aWs}{aWs}\,\frac{sP}{sP}$, $\frac{AwS}{AwS}\,\frac{Sp}{Sp}$, $\frac{AwS}{AwS}\,\frac{Sp}{Sp}$ (cf. Diagram 3), but when *p* goes to the same pole as


aWs sP
Diagram 3 × → aWs sP / AwS Sp
AwS Sp
Unisexual mycelia
Diploid stage
aWs sP
Diagram 4 × → aWs sP / AwS Sp
AwS Sp
1 aWs sP
2 aWs sP
3 AwS Sp
4 AwS Sp
First division
1 aWs sP
2 Aws sp
3 aWS Sp
4 AwS SP
1 aWs sP
2 aWs sP
3 AwS Sp
4 AwS Sp
Second division
1 aWs sP
2 Aws sp
3 aWS Sp
4 AwS SP
Third division
1 aWs sP aWs sP 2 aWs sP aWs sP
3 AwS Sp AwS Sp 4 AwS Sp AwS Sp
1 aWs sP Aws sp 2 aWs sP Aws sp
3 aWS Sp AwS SP 4 aWS Sp AwS SP

a the formula of the ascospores would be $\frac{aWs}{aWs}\frac{Sp}{Sp}$, $\frac{aWs}{aWs}\frac{Sp}{Sp}$, $\frac{AwS}{AwS}\frac{sP}{sP}$, $\frac{AwS}{AwS}\frac{sP}{sP}$. Since the occurrence of two factors of the same sex reaction in one ascospore would cause sterility, this type of behavior is not typical for untreated cultures of *N. tetrasperma*.

It may now be assumed that the spindles have a longitudinal arrangement in the second division and that the *A* and *p* factors show fifty per cent crossing-over with the spindle-fiber attachment. Since it is evident from an inspection of Diagram 4, that every ascospore would contain a dominant and a recessive factor, this method of segregation can not explain the results of this experiment. If it is assumed, however, that the *A* factor shows fifty per cent and that the *p* factor shows twenty-five per cent crossing-over with the spindle-fiber attachment a different result is obtained. According to this hypothesis all of the resulting cultures would show some fertility because all of the ascospores would contain an *A* and *a* factor. As far as the *p* factor is concerned half of the asci would segregate according to the method shown in Diagram 3, and half according to the method shown in Diagram 4. Those segregating according to the first method would consist of two normal and two semi-fertile cultures, whereas those segregating according to the second method would consist of four normal cultures. When reduced to the simplest terms these results give a ratio of three normal to one semi-fertile culture. When segregation occurs according to Diagram 4, double crossing-over must also be considered. Since there are three ways in which this phenomenon can occur, progressive, independent and recurrent, the constitution of the ascospores for these three types would be $\frac{aWs}{Aws}\frac{sP}{sp}$, $\frac{aWs}{Aws}\frac{sP}{sp}$, $\frac{aWS}{AwS}\frac{Sp}{SP}$, $\frac{aWS}{AwS}\frac{Sp}{SP}$ or $\frac{aWs}{Aws}\frac{sp}{sP}$, $\frac{aWs}{Aws}\frac{sp}{sP}$, $\frac{AwS}{aWS}\frac{SP}{Sp}$, $\frac{AwS}{aWS}\frac{SP}{Sp}$; or $\frac{aWs}{Aws}\frac{sP}{sp}$, $\frac{aWs}{Aws}\frac{sP}{sp}$, $\frac{aWS}{AwS}\frac{SP}{Sp}$, $\frac{aWS}{AwS}\frac{SP}{Sp}$ respectively. As a consequence, the same types of unisexual spores would be obtained as those shown in Table 1. Additional evidence on these two

theories will be forthcoming (cf. Malloch, in press). At this time the behavior of several F_2 progenies, which were grown from the cultures described in Table 1, will be presented.

The asci (cf. Table 1, Nos. 2.0–3.0) which segregated into two normal and two semi-fertile cultures will be considered first. This category consists of two bisexual and four unisexual types which will be discussed in turn. When F_2 generations were grown from four of the semi-fertile cultures (cf. Table 1, No. 3.0), the resulting bisexual cultures were all semi-fertile, $\frac{Aw}{aW}\frac{p}{p}$, while the unisexual cultures consisted of the fluffy orange, $aW\ p$, and the light dwarf types, $Aw\ p$. Since the semi-fertile cultures bred true to type, they must be homozygous for the p factor. The genetic constitution of the semi-fertile type was confirmed by the isolation of the unisexual types (cf. Table 2). When the

TABLE 2

F_2 PROGENY OBTAINED FROM ASCOSPORES WHICH HAD THE GENETIC CONSTITUTION $\frac{aW}{Aw}\frac{p}{p}$

Number of experiment	75–F_2	$D_1 \times Ta$ 76–F_2	78–F_2	79–F_2	$W_{81} \times Ta$ 1–F_2
Type of asci as shown by progeny					
1A Semifertile	15	18	17	12	14
Unisexual types $aW\ p$	3	4	3	1	5
Unisexual types $Aw\ p$	0	1	0	0	0
Progeny from spore print					
1B Semifertile	23	28	81	51	63
Unisexual types $aW\ p$	15	6	9	8	2
Unisexual types $Aw\ p$	4	5	7	3	1

fluffy orange (cf. Table 1, No. 3.1) and the light dwarf types (cf. Table 1, No. 3.2) were mated, the F_1 hybrid exhibited the characteristics of the semi-fertile type. Since the F_2 generation of this mating again bred true to the semi-fertile condition, the behavior of this type is completely established. In *N. tetrasperma*, the unisexual types represent but a small proportion of the population, and since they are slow in developing, it is frequently necessary to isolate them from spore prints.

The analysis of the normal bisexual cultures (cf. Table 1,

No. 2.0) which had the genetic constitution $\frac{aW}{Aw}\frac{P}{P}$ will be considered next. As shown in Table 3 seven F_3 progenies consisted of the normal bisexual, the normal orange and the dark dwarf types. Since the bisexual cultures bred true to type, they must be homozygous for the *P* factor. The isolation of the two unisexual types, which were theoretically expected, confirm the genetic constitution of the bisexual cultures. The behavior of the two unisexual strains will now be considered.

TABLE 3

F_2 PROGENY FROM THE HYBRID MATING Ta×D_1

The ascospores from which these cultures were raised had the genetic constitution $\frac{aW}{Aw}\frac{P}{P}$.

Number of experiment	Ta×D_1						
	$2F_2$	$4F_2$	$5F_2$	$6F_2$	$9F_2$	$12F_2$	$13F_2$
Type of asci as shown by progeny							
All normal bisexual types	23	18	19	14	17	16	12
Unisexual types *aW P*	1	2	1	3	4	5	1
Aw P	1	0	0	0	0	0	0
Progeny obtained from a spore print							
All normal bisexual types	110	47	46	46	59	57	86
Unisexual types *aW P*	4	2	2	4	16	1	6
Aw P	5	4	4	5	20	1	3

When the normal orange unisexual type, *aW P* (cf. Table 1, No. 2.1), was mated with the standard sex strain, *AW P* (No. TIA), the F_1 generation resembled the normal bisexual type. The F_2 progeny from this cross consisted of 55 normal bisexual cultures, two normal orange, *aW P*, and three normal pale, *AW P*, types. Since the rate of growth was normal in each derivative type, the factor *W* must have been present in each strain. The presence of factor *P* was confirmed by the occurrence of normal perithecia and ascospore production.

The dark dwarf type, *Aw P* (cf. Table 1, No. 2.2), grew at the same rate as the light dwarf type, but it reacted in a different way. When this unisexual type was mated with the normal orange type, *aW P* (cf. Table 1, No. 2.1), the F_2 generation consisted of normal bisexual cultures, the normal orange type and

the dark dwarf type (cf. Table 4). In this cross the factor *W*, which was introduced by the normal orange type was completely dominant over the *w* factor. The occurrence of normal perithecia and ascospore production in all of the progeny indicated that each unisexual type carried factor *P*. These experiments complete the analysis of those asci which segregated into two normal and two semi-fertile cultures.

TABLE 4

RESULTS OBTAINED FROM A MATING BETWEEN THE DARK DWARF TYPE *Aw P* AND THE NORMAL ORANGE TYPE *aW P*

Number of experiment	D39×Y17	D39×Y18
Type of asci as shown by progeny		
All normal bisexual types	13	14
Unisexual types *aW P*	2	1
Aw P	0	0
Progeny derived from a spore print		
Normal bisexual types	79	75
Unisexual types *aW P*	6	8
Aw P	7	2

Those asci which produced all normal cultures in the cross between the light dwarf type and the standard sex strain (cf. Table 1, No. 1.0) will be analyzed in the same way. Nine progenies which were grown from the bisexual cultures are shown in Table 5. These segregated in a ratio of 3 normal bisexual to 1 semi-fertile culture in addition to producing the normal orange, the dark dwarf, the fluffy orange and the light dwarf types. Additional progenies which were grown from spore prints are shown in Table 6. The chi-square and *P* values listed in Tables 5 and 6 indicate that there was good agreement between the expected ratio of 3 : 1 and the observed facts. The unisexual strains belonging to this category will now be discussed.

When the normal orange unisexual type, *aW P* (cf. Table 1, No. 1.1), was mated with the standard sex strain, No. TIA, the progeny consisted of 83 normal bisexual cultures, two normal orange and three normal pale unisexual cultures. Since this mating was homozygous for all factors except the *Aa* pair, it confirms the nature of one of the unisexual types postulated in Diagrams 1 and 2.

TABLE 5

F_2 PROGENIES RAISED FROM THE NORMAL F_2 CULTURES OF THE MATING Ta × D_1

The ascospores from which these cultures were raised had the genetic constitution of $\frac{aW\ p}{Aw\ P}$ or $\frac{aW\ P}{Aw\ p}$.

No. of experiment		1–F_3	3–F_3	7–F_3	8–F_3	10–F_3	11–F_3	14–F_3	15–F_3	17–F_3
Type of asci as shown by progeny										
1. All normal.....		13	15	16	16	13	19	16	13	14
Unisexual forms	*aW P*	4	4	3	2	2	5	2	1	2
	Aw p	0	0	0	0	0	0	0	0	0
	Aw P	0	0	0	0	0	0	0	0	0
	aW p	0	0	0	0	0	0	0	0	0
2. Two normal : two semi-fertile...		11	10	13	14	10	15	15	10	12
Unisexual forms	*aW P*	1	2	1	3	1	1	0	1	2
	Aw P	0	0	0	0	0	0	0	0	0
	aW p	2	2	4	3	1	4	4	3	2
	Aw p	0	0	0	0	0	0	0	0	0
Test for 3 : 1 ratio	X^2...	.2223	1.3333	.4137	.1777	.5217	.6275	.0431	.5217	.7619
	P....	.70–.50	.30–.20	.70–.50	.70–.50	.50–.30	.50–.50	.90–.80	.50–.30	.50–.30

TABLE 6

THESE PROGENIES ARE THE SAME AS SHOWN IN TABLE 5 BUT THE ASCOSPORES WERE OBTAINED FROM A SPORE PRINT

No. of experiment		1–F_3	3–F_3	7–F_3	8–F_3	10–F_3	11–F_3	14–F_3	15–F_3	17–F_3
Progeny obtained from spore print										
1. Normal bisexual		66	38	37	34	28	46	60	64	52
2. Semi-fertile.....		18	9	8	8	7	8	17	23	11
3. Unisexual	*aW P*	2	2	5	8	5	1	4	10	3
	Aw p	1	2	1	2	1	2	4	2	3
	Aw P	1	3	0	1	2	3	2	5	0
	aW p	6	3	3	6	2	0	9	4	6
Test for 3 : 1 ratio	X^2...	.5715	.8521	1.2519	.7936	.4667	2.9876	.3507	.0957	1.9100
	P....	.50–.30	.50–.30	.30–.20	.50–.30	.50–.30	.10–.05	.70–.50	.80–.70	.20–.10

When the light dwarf segregate (cf. Table 1, No. 1.2) was mated to the standard sex strain No. Ta, an F_2 population was obtained (D_{46} × Ta), which segregated into a ratio of sixty normal bisexual to eighteen semi-fertile cultures. This mating followed the type of segregation shown in Diagrams 1 and 2 and confirmed the nature of the light dwarf segregate.

By analyzing the bisexual and unisexual types from an X-rayed derivative of *N. tetrasperma*, it has been shown that the new

alterations behaved like gene mutations. This was true regardless of whether the mutant types were mated between themselves or with the standard sex strains. The only point which was not determined was the linkage relationships of the *p* factor. Since *p* was the only factor which exhibited crossing-over in these matings, it was immaterial whether this factor was located upon the same chromosome with *A*, or upon a separate one. This question will be discussed in the next paper, because the linkage groups can be described to the best advantage in connection with the four remaining types derived from culture No. 42.

DISCUSSION

While fertilization and meiosis are the two important phases in the genetic behavior of seed plants, the method of spore formation may play an important role in the development of fungi. This is true in *Neurospora* because in this group both homothallic and heterothallic species are found. In both groups there are two types of haploid nuclei, each of which contains one set of chromosomes. One chromosome of each set carries either an *A* or *a* factor. Both heterothallic and homothallic species produce eight nuclei in the ascus as a result of three nuclear divisions. The important difference between the two groups, however, occurs at the time of spore formation, for this is the process which determines whether the ascospores and resulting mycelium shall be monocaryotic or dicaryotic in nature.

Since the ascospores of *N. crassa* are monocaryotic, the question of dominance is excluded, although bisexual ascospores sometimes occur (cf. Lindegren, **1934**). According to the descriptions given by Lindegren (**1936**), certain characters may be epistatic and others hypostatic. The three factor pairs *Aa*, *Ww*, and *Pp*, which were studied in this investigation, demonstrate that the normal development of an organism depends upon the interaction of many genetic factors. The effect of these genes upon growth may be considered first. In a monocaryotic mycelium factors *P* and *p* are hypostatic to factors *W* and *w*, as may be seen from the following evidence: In the presence of *W* factor *P* produces the normal type of growth (the normal orange type, *aW P*,

and the normal pale type, *A W P*), while *p* conditions a very vigorous and fluffy type of mycelial growth (the fluffy orange type, *aW p*, and the fluffy albino type, *A W p*). In strains carrying factor *w*, however, a dwarf type of monocaryotic mycelium is produced in the presence of either *P* or *p* (the light dwarf, *Aw p*, and the dark dwarf type, *Aw P*). It is evident, therefore, that factors *W* or *w* determine whether the mycelium of a unisexual culture shall be vigorous or dwarf, while factors *P* or *p* produce modifications of these types. In a dicaryotic mycelium the factor pairs *PP* or *Pp* condition normal growth in the presence of *WW* or *Ww*, while the *pp* factor pair produces a fluffy growth.

The relationship of the three factor pairs to conidiospore color may now be considered. In the matings considered here *A* and *w* were absolutely linked, so that the effect of *w* upon conidiospore color could not be determined. It will be shown in the next discussion that when a cross-over does occur the resulting forms are a shade darker than the types discussed here. In an earlier paragraph it was mentioned that Dodge (**1935a**) and Tai (**1936**) found that a factor *O* for salmon orange conidia was strongly linked with the factor for Sex *a*. In interspecific hybrids this relationship was broken down so that many cross-overs were obtained (cf. Dodge, **1936**). When studied by the method of ascus dissection, there was practically no possibility of misclassifying the distinctive types studied here. The linkage between *a* and *O* was very strong since no cross-over were obtained. As a consequence the symbol *O* has not been used in the formulae given in this paper. The normal orange unisexual type, *aW P*, and the fluffy orange type, *aW p*, have salmon orange conidiospore color due to the presence of factor *a*, regardless of the presence of *P* or *p*. Likewise, the normal pale unisexual type, *A W P*, the fluffy albino type, *A W p* (to be discussed in the following paper), the light dwarf, *Aw p*, and the dark dwarf, *Aw P*, have pale salmon conidiospore color, due to the presence of factor *A*, the *P* and *p* factors apparently having no effect. These factors play an important role in dicaryotic cultures, however, in that the salmon orange color characteristic of factor *a* was dominant over salmon pink in the presence of

PP or *Pp*, but an orange pink was produced when the factor pair *pp* was present.

In this experiment the color of the substratum was not due to one factor, such as *M* (cf. Tai, **1936**), but to the interaction of two factor pairs, *Aa* and *Pp*. The following data indicate that *A* and *a* were hypostatic to *P*. In cultures in which factor *P* or the factor pairs *PP* or *Pp* were present, a chestnut brown color was found in the surface mycelium (normal orange type, *aW P*; normal pale type, *AW P*; dark dwarf type, *Aw P*; and the normal bisexual type). The effect of *A* and *a* on the color of the substratum could be determined in cultures in which factor *p* was present. Since the fluffy orange type, *aW p*, with an orange colored substratum, and the fluffy albino type, *AW p*, with a colorless substratum, differ only in the *A* and *a* factors, the latter must be responsible for the color difference. When the *p* factor is homozygous, as in the semi-fertile type, the color of the substratum was intermediate (orange pink) between salmon orange and salmon pink.

The discussion thus far has shown that different genetic factors interact in the diploid cell to produce results not found in the haploid cell. While these results support the definition of the diploid cell as given by Buller (**1941**), it is necessary to explain how the factors in two separate nuclei may interact to produce different genetic phenomena. Judging from the experiments and hypotheses published thus far the most promising method of approach is from the chemical standpoint (cf. review by Goldschmidt, **1938**).

While a number of chemical reactions have been studied in fungi (cf. review by Malloch, **1940**), only the results obtained from the genus *Neurospora* will be mentioned here. As a result of chemical studies with *N. sitophila* it was shown that this species can form a number of different enzymes, which, with the exception of trehalse, are secreted in the culture solution. The production of these enzymes, however, was dependent upon the presence of specific compounds in the nutrient solution (cf. Went, **1901**, **a**, **b**, **c**). In recent investigations by Beadle & Tatum (**1941**) X-rayed strains were tested for loss of synthetic abilities by transferring them to minimal media. A number of

mutants were obtained which were unable to synthesize specific chemical compounds, such as vitamin B_1. Each of them differed from the control by a single gene, and each was made indistinguishable from normal by adding the specific substance that it could not synthesize. These facts were considered consistent with the assumption that each of the genes involved was concerned with the control of one and only one chemical reaction. Since chemical compounds are manufactured in the cell and secreted into the culture media there is no reason why these compounds should not react in the cytoplasm to produce intermediate effects such as the ones noted here. While this subject will be enlarged upon at another time, it is now necessary to turn to the consideration of other genetic phenomena.

Methods whereby genetic ratios may be produced in homothallic Ascomycetes have been illustrated by several diagrams. Since the cytological evidence indicates that the spindles can be arranged in either an oblique or longitudinal direction during the second division (cf. Dodge, **1927**; Colson, **1934**) it would suggest that after this division there would be a pair of sister nuclei in each end of the spore plasm all in one row. Dodge (**1927**), however, never found such an orientation of the reorganizing nuclei in *N. tetrasperma*. He assumes that a shifting in position must occur, so that a pair of nonsister nuclei will come to lie in each end of the ascus. Later (cf. Dodge, **1936**), the longitudinal arrangement of the spindles was suggested as a possible explanation for certain types of segregation. It has been shown in the present paper that a 3 : 1 ratio can be obtained by either arrangement, but due to the wide divergence in the percentage of crossing-over necessary to explain this ratio by the two methods, it would appear that the two hypotheses are mutually exclusive. This would support the assumption that the spindles must shift their position before the ascospores are finally cut out. If we assume that the same percentage of crossing-over is present in both cases there are certain populations where both the oblique and longitudinal arrangements could occur (cf. Malloch, in press). Obviously, this is a subject which is of considerable importance to mycology, but its solution demands more critical evidence.

Dodge (**1939**) and Lindegren and Lindegren (**1941**) described new types which behaved like those due to chromosomal alterations. While evidence of chromosomal alterations was found in the progeny of culture No. 42, the types described in this report behaved like gene mutations. By growing F_2 populations it was shown in a previous investigation (cf. Malloch, **1941**) that bisexual X-rayed derivatives of *N. tetrasperma* are frequently heterozygous and that segregation of different characters may occur. Culture No. 42 is a strain which was heterozygous for two X-ray induced mutations, but stable types could be established in the third generation. In contrast to these results, many of the unisexual cultures were stable from the first generation. The previous conclusions (cf. loc. cit.) have been confirmed in that the association of certain characters may be due to a single factor, such as *p*, or to the linkage of two factors like *A* and *w*.

Evidence from several investigations suggests that increased vigor is found in some species of fungi following X-radiation. The fluffy orange and semi-fertile types, which were described in this paper are an illustration of this phenomenon. This increase in vegetative growth, however, may have been caused by the absence of the factors for normal perithecia and ascospore production.

SUMMARY

1. Eight character combinations, which were derived from one X-rayed ascospore of *Neurospora tetrasperma*, were analyzed in this investigation.

2. A genetic study of these characters indicated that the different types were governed by three pairs of factors, *Aa*, *Ww*, and *Pp*. The factor pair *Aa* governs sex expression, *A* being associated with pale, and *a* with salmon-orange conidiospore color. *W* and *w* are factors affecting the form of hyphal growth, *W* being a dominant factor for normal, and *w* a recessive factor for a dwarf type of growth. *W* is strongly linked to *a* and *w* to *A*. The factor pair *Pp* governs perithecia development, *P* being associated with normal perithecia and ascospore production, and *p* with reduced perithecia and ascospore development.

3. Different genetic combinations are produced by various interactions between these factors.

4. The X-ray induced alterations studied in this investigation behave like gene mutations. The instability of such characters which has been noted in other organisms, was not a prominent feature of the genes discussed here.

5. The segregation of genetic factors in *N. tetrasperma* is affected by the following phenomena: the inclusion of non-sister nuclei by the cell wall during ascospore formation, the occurrence of crossing-over, the arrangement of the spindles during the second division and the orientation of the chromosomes with respect to the poles of the spindles during the second division. As a consequence of these conditions a culture, which was heterozygous for the three pairs of factors noted above, segregated into a ratio of 3 normal to 1 semi-fertile culture.

6. The occurrence of unisexual ascospores in this species, which produces bisexual spores for the most part, furnishes a method for detecting the segregation of certain recessive characters.

7. *N. tetrasperma* should be a favorable organism with which to investigate the nature of chemical substances produced by different genes, since both the unisexual and bisexual types are available. Although conjugate nuclei may produce chemical substances which, by reacting in the cytoplasm, produce new compounds necessary for the development of certain organs, the production of the substances themselves must ultimately be controlled by genetic factors.

8. As evidenced by the increased vigor of certain cultures, X-radiation provides a method for the creation of valuable new strains of fungi.

In closing, the writer takes pleasure in expressing his appreciation to Professors T. H. Goodspeed, Lee Bonar and W. C. Snyder under whose direction this study was carried out and to Professor A. Davis who extended the privileges of the botany laboratories. The author wishes to express his thanks to Professor J. Neyman for advice in regard to the statistical methods used in this series of investigation and to Mrs. F. W. Malloch and Mr. W. G. Malloch for valuable assistance in

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REFERENCES

Beadle, G. W. & Tatum, E. L. 1941. Genetics of biochemical characters in *Neurospora*. Rec. Genetics Soc. Am. **10**: 130–131.

Buller, A. H. Reginald. 1941. The diploid cell and the diploidisation process in plants and animals, with special reference to the higher fungi I, II. Bot. Rev. **7**: 335–387; **8**: 341–389.

Colson, Barbara. 1934. The cytology and morphology of *Neurospora tetrasperma* Dodge. Ann. Bot. **48**: 211–224.

Dodge, B. O. 1927. Nuclear phenomena associated with heterothallism and homothallism in the Ascomycete *Neurospora*. Jour. Agr. Res. **35**: 289–305.

Dodge, B. O. 1934. A lethal for ascus abortion in *Neurospora*. Mycologia **26**: 360–376.

Dodge, B. O. 1935. A recessive lethal for ascospore formation in *Neurospora*. Bull. Torrey Club **62**: 117–128.

Dodge, B. O. 1936. Interspecific hybrids involving factors for ascus abortion in *Neurospora*. Am. Jour. Bot. **23**: 555–561.

Dodge, B. O. 1939. A new dominant lethal in *Neurospora*. Jour. Heredity **30**: 467–474.

Dodge, B. O. 1941. A heritable factor complex for heterocaryotic vigor in *Neurospora*. Rec. Genetics Soc. Am. **10**: 140–141.

Dodge, B. O. & Seaver, Bernice. 1938. The combined effects of the dominant and the recessive lethals for ascus abortion in *Neurospora*. Am. Jour. Bot. **25**: 156–166.

Goldschmidt, R. 1938. Physiological genetics. 375 pp. New York, McGraw-Hill.

Goodspeed, T. H. 1942. Experimental induction of heritable and other alterations in the fungus *Neurospora tetrasperma*. Proc. Eighth Am. Sci. Cong.

Lindegren, Carl C. 1932. The genetics of *Neurospora* II. Segregation of the sex factors in asci of *N. crassa*, *N. sitophila*, and *N. tetrasperma*. Bull. Torrey Club **59**: 119–138.

Lindegren, Carl C. 1933. The genetics of *Neurospora* III. Pure bred stocks and crossing-over in *N. crassa*. Bull. Torrey Club **60**: 133–154.

Lindegren, Carl C. 1934. The genetics of *Neurospora* VI. Bisexual and akaryotic ascospores from *N. crassa*. Genetica **16**: 315–320.

Lindegren, Carl C. 1936. A six point map of the sex-chromosome of *Neurospora crassa*. Jour. Genet. **32**: 243–256.

Lindegren, Carl C. & Lindegren, Gertrude. 1941. X-ray and ultra-violet induced mutations in *Neurospora*. Jour. Heredity **32**: 405–412.

Malloch, Walter Scott. 1940. The artificial induction of mutations in *Neurospora tetrasperma*. Dissertation 412 pp. Univ. of Calif.

Malloch, Walter Scott. 1941. The association of different alterations in self-fertile X-rayed derivatives of *Neurospora tetrasperma*. Mycologia **33**: 540–554.

Malloch, Walter Scott. In press. The effect of crossing-over on the inheritance of X-ray induced mutations in *Neurospora tetrasperma*.

Ridgway, Robert. 1912. Color standards and color nomenclature. 43 p. LIII col. pl. The author. Washington, D. C.

Shear, C. L. & Dodge, B. O. 1927. Life histories and heterothallism of the red bread-mold fungi of the *Monilia sitophila* group. Jour. Agr. Res. **34**: 1019–1042.

Tai, F. L. 1936. Sex-reaction linkage in *Neurospora*. Mycologia **28**: 24–30.

Uber, Fred M. & Goddard, David R. 1934. Influence of death criteria on the X-ray survival curves of the fungus *Neurospora*. Jour. Gen. Physiol. **17**: 577–590.

Went, F. A. F. C. 1901a. Ueber den Einfluss der Nahrung auf die Enzymbildung durch *Monilia sitophila* (Mont.) Sacc. Jahrb. Wiss. Bot. **36**: 611–664.

Went, F. A. F. C. 1901b. *Monilia sitophila* (Mont.) Sacc. ein technischer Pilz. Javas. Zentbl. Bakt. IIE. **7**: 544–550.

Went, F. A. F. C. 1901c. *Monilia sitophila* (Mont.) Sacc. ein technischer Pilz Javas. Zentbl. Bakt. IIE. **7**: 591–598.

Wuekler, Heinz. 1935. Untersuchungen ueber Tetradenaufspaltung bei *Neurospora sitophila* Shear und Dodge. Z. Indukt. Abstamm. Vererblehre **69**: 210–248.

NOTES AND BRIEF ARTICLES

Mycologia

Mycologia has closed another successful chapter. The volume for 1941 consisted of 717 pages. The articles have been carefully selected and the character of the work speaks for itself. The total receipts for the year were $4696.93, almost exactly the same as that for the preceding year. The total expenditures for the year were $3769.03, leaving an accumulated balance of $1722.79. Of this $1000, which had been accumulated from the sale of back sets and interest was added to the Endowment Fund. This brings our Endowment to $8000, leaving an unexpended reserve of $722.79.

While Mycologia is in an excellent financial condition up to the present time, we nevertheless face one of the most critical years in our history, owing to the fact that the war has cut off most of our income from European and Asiatic countries, at least for the time being. This loss is estimated at $700 or more. While we have sufficient reserve to cover this loss for the present, it will not continue to do so and we must look for new blood in our own country if we wish to maintain our activities at their present pace.

Last year a membership committee was appointed of which the writer was asked to serve as Chairman. This committee was active during the year and secured a considerable number of new members. At the last meeting in Dallas the committee was continued, and a strenuous campaign will be conducted through the present year to still further increase our memberships, and each member of the Society is hereby requested to consider himself a committee of one to help in this enterprise.—Fred J. Seaver.

Review

Degelius, Gunnar. Contributions to the Lichen Flora of North America. II. The Lichen Flora of the Great Smoky Mountains. Arkiv för Botanik **30 A**: 1–80. 7 figures and 2 plates. 1941.

This is the second in a series of studies of the lichen flora of North America by the same author. The area involved is that limited by the boundaries of the Great Smoky Mountains National Park.

In discussing general composition and vertical distribution, the author points out that though the lichen flora of the area is rather poor, the lichen vegetation is rich. However, the list of 206 species, a few of which have not been definitely determined, includes some extremely interesting finds.

The following 15 new species are described: *Staurothele tenuissima* Degel., *Microthelia inops* Degel., *Pleurotrema solivagum* Degel., *Arthonia biseptata* Degel., *Lecidia Degelii* H. Magn., *L. deminutula* H. Magn., *L. gyrodes* H. Magn., *L. subtilis* Degel., *Rhizocarpon intermedium* Degel., *Stereocaulon tennesseense* H. Magn., *Lecanora (Aspicilia) olivaceopallida* H. Magn., *L. insignis* Degel., *Parmelia lobulifera* Degel., *Physcia subtilis* Degel., and *Anaptychia squamulosa* Degel. In addition, three new varieties: *Lecidea helvola* (Korb.) Th. Fr. v. *longispora* Degel., *L. olivacea* (Hoffm.) Mass. v. *inspersa* Degel., *Parmelia sorocheila* Vain. v. *catawbiensis* Degel., and one new form: *Umbilicaria papulosa* (Ach.) Nyl. f. *lacerata* Degel., are described. *Pleurotrema solivagum* Degel. represents a family new to North America, the chiefly tropical Paratheliaceae.

Seven species found in the Great Smoky Mountains have not been previously reported from North America: *Arthopyrenia pinicola, Leptoraphis quercus, Catinaria albocincta, Ochrolechia Yasudae, Arthonia caesia, Parmelia dissecta,* and *Physcia Wainioi. Erioderma* is a genus new to North America; one species is reported, *E. mollissimum.* Six species have not been reported previously from the United States: *Pyrenula bahiana, P. brunnea, Parmelia sorocheila, Physcia mclops, Anaptychia corallophora,* and *A. sorediifera.*

The author lists a number of species, found within the Great Smoky Mountains National Park, which have been hitherto reported from a limited number of points in the United States or from entirely different parts of the country. This list, of interest from a phyto-geographic standpoint, includes: *Arthopyrenia fallax, Leptoraphis contorta, Opegraphia cinerea, Crocynia neglecta, Ther-*

mutis velutina, Pyrenopsis subfuliginea, Leptogium americanum, Pseudocyphellaria Mougeotiana, Nephroma parile, Lecidea granulosa, L. helvola, L. mollis, L. subsimplex, Bacidia chlorantha, B. endocyanea, Rhizocarpon plicatile, Rh. reductum, Cladonia impexa, Cl. mitis, Stereocaulon pileatum, Pertusaria amara, P. laevigata, P. leioterella, Lecanora hypoptoides, L. pinastri, Parmelia Arnoldii, P. cetrarioides, P. revoluta, P. subaurifera, P. trichotera, P. tubulosa, Cetraria ciliaris, Alectoria altaica, A. bicolor, and *A. sarmentosa.*

Though lacking in illustrative material, this paper is a valuable contribution to knowledge of the lichen flora of North America.—S. L. MEYER.

MYCOLOGICAL SOCIETY OF AMERICA

REPORT OF THE 1941 FORAY

(WITH 1 FIGURE)

The 1941 Summer Foray of the Mycological Society of America was held at Macdonald College, Quebec, August 25–28. The local arrangements were made by Dr. Ivan H. Crowell of the Department of Plant Pathology at the College and Mr. Henry A. C. Jackson of Montreal, who planned a well-organized Foray and provided every convenience that was possible or desired. The College opened the women's dormitory and dining-room for the use of the group. Such an arrangement is always an excellent feature because it makes for greater sociability and allows more contact for profitable discussion. The well-equipped Plant Pathology laboratory provided every facility for an event of this kind.

Forty-one people in all attended. Twenty-two of these were mycologists and the remainder wives and children or other visitors. Unfortunately, only five members of the Society from the United States were able to attend, in all probability largely because of the ill-timed agitation about the gas shortage just prior to the time for starting for the Foray. M. Dr. Georges Maheux, Provincial Entomologist of the Department of Agriculture, was the official representative of the Province of Quebec.

Excellent collecting grounds had been selected at Morgan's Woods near the College and on Île Jesus and Île Perrot by Messrs. Crowell and Jackson, with the assistance of Messrs. William Brown and Henry Mousley, ornithological friends of Mr. Jackson. The collecting was fair but not as good as it should have been for these

1941 FORAY AT MACDONALD COLLEGE, QUEBEC.
PHOTOGRAPH BY MAURICE B. WALTERS.

localities on account of the prevailing dry weather following adequate rain some time before.

On Tuesday afternoon, Mrs. Crowell entertained the ladies at tea.

On Tuesday evening in one of the laboratories there was an exhibit of the superb water-color drawings of fungi by Henry A. C. Jackson and of excellent colored photographs of fungi by Maurice B. Walters.

On Wednesday evening there was a business meeting with the Vice President of the Society presiding and with Dr. Crowell

acting as Secretary of the meeting. The following resolutions were passed: the thanks of the Society to Dean W. H. Brittain of Macdonald College for his invitation to hold the Foray at this institution; commendation of Messrs. Crowell, Jackson, Brown and Mousley for their efforts in making the Foray a success; thanks to Miss Geneva Jackson for her drawing of the serio-comic sketch-map of the approaches to the College and of the collecting grounds; sympathy to Dr. Dearness in his recent bereavement; expression of regrets to Messrs. Overholts, Whetzel and Beardslee, quite regular attendants at past Forays, at their inability to attend this year. It was voted to publish a complete list of the fungi collected, to be compiled by the Vice President as soon as the several lists may be completed. There was discussion of the place for the next Foray, which in general was heartily in favor of accepting an invitation from Dr. Bessey to go to Michigan should his invitation of this year be repeated.

After the business meeting, in the Stewart room of the dormitory the group was entertained by M. Dr. Maheux and Dr. Groves —the former with his songs in French at the piano and in leading songs participated in by the whole group as only he can entertain, and by the latter with very artistic renditions at the piano.

On Thursday afternoon the entire group drove to the Botanical Garden of the University of Montreal and participated in an event of great interest to all those present—the dedication of the John Dearness Laboratory of Plant Pathology to the first and foremost Canadian mycologist and the beloved friend of all American mycologists. The ceremonies were opened by an address by Fr. Marie-Victorin, the eminent Canadian taxonomist, who outlined the purpose of the occasion and extolled the attainments of Dr. Dearness. Dr. Dearness then responded in his very original manner in a most pleasing way, with a brief history of the development of mycology, its relation to other botanical sciences and its value as a hobby and intellectual stimulus, without, however, failing to pay entertaining attention to the children present. The Vice President responded for the Society and for American botanists in general in commending the authorities of the Botanical Garden for their graciousness in thus honoring Dr. Dearness and in congratu-

lating him as so highly deserving of such an honor. Following these ceremonies the group was conducted upon an inspection tour of the building and finally to the Laboratory of Plant Pathology, where Dr. Dearness was handed the key to open it officially. Then the group proceeded to the Garden restaurant to enjoy refreshments, with Mm. Drs. Brunel and Jacques as hosts.—WALTER H. SNELL, VICE PRESIDENT.

PHYTOPATHOLOGICAL CLASSICS

A new Phytopathological Classic No. 7 is now available. This consists of four classical papers on virus diseases translated from the German by Dr. James Johnson of the University of Wisconsin. These papers are:

1. **Concerning the mosaic disease of tobacco**
   by Adolf Mayer, 1886.
2. **Concerning the mosaic disease of the tobacco plant**
   by Dmitrii Ivanowski, 1892.
3. **Concerning a contagium vivum fluidum as a cause of the spot-disease of tobacco leaves**
   by Martinus W. Beijerinck, 1898.
4. **On the etiology of infectious variegation**
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INDEX TO MYCOLOGIA EUROPAEA

The Farlow Library has published a small edition of an Index to Mycologia Europaea by C. H. Persoon (1822–28). The Index was compiled by Dr. and Mrs. Donald P. Rogers, and it lists alphabetically all fungus names and the volumes and pages where

they occur. In case a name was used as a synonym the page reference has been printed in italics.

Because until now it lacked an index this important contribution to mycological taxonomy has been hard to use and therefore often ignored.

A copy of this useful Index will be sent to all who are on the regular exchange list of the Farlow Library. The few remaining copies may be purchased by interested individuals and institutions for twenty-five cents each.—EDGAR V. SEELER, JR.